COLONY AND PROTECTORATE OF KENYA

DEPARTMENT OF AGRICULTURE
ANNUAL REPORT
1960

Volume II—Record of Investigations

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INTRODUCTION BY THE CHIEF RESEARCH OFFICER

As a result of further cuts in funds allocated to the activities of the Research Division a comprehensive review of the whole field of work is being undertaken. The object of this is to ensure that the funds available are put into those projects most likely to lead to increased production or result in the alleviation of recurrent food shortages in the marginal areas of the country and a better standard of nutrition for the indigenous population generally.

Some industries have continued to spend their own money in support of agricultural research and with these the drive to get new information to improve production has suffered no setback and has in fact increased in some cases. The coffee, sisal, pyrethrum, cereals and cotton industries are notable cases in point.

Generous financial assistance has again been received from C.D. & W. funds, the Rockefeller Foundation and the International Co-operation Administration of the U.S.A.

This volume presents the fuller reports of the Agricultural Research sections reviewed in brief in Volume I.

As the fund of information derived from many years of research work builds up—it becomes increasingly apparent that much more effort must be put into the dissemination of the results of this work and considerable emphasis has been placed during the year on the need to get work written up and published.

In introducing the present report the following comments highlight some of the more noteworthy results of the year's work.

The work on Coccid taxonomy has resulted in the publication of a paper dealing with the descriptions of a first group of thirty new African mealybugs.

The result of the experimental programme to appraise the use of large polyethylene covers as a means of protecting bagged produce from reinfestation by secondary storage pests is that the technique can now be applied commercially.

The pests of small grained cereals required a lot of attention during the year particularly *Barley Fly*, *Nematocerous* and Dusty Ground Beetle. Laboratory tests on newly hatched larvae of *Nematocerous* indicated a wide tolerance of insecticides.

Soil survey work continued in the Nakuru area where a further 60,000 acres were surveyed bringing the completed total in this area to 140,000 acres. Another survey was undertaken in the Nanyuki district in collaboration with the Hydraulic Branch of the Ministry of Works to select soils for potential irrigation development; about 320,000 acres were surveyed of which 25,000 acres are suitable for irrigation.

Further progress has been made in the delineation of the copper deficient soils in the Nakuru area by the use of pot tests. In addition an experiment on the effect of copper sulphate applications to wheat on three of the major soil types of the deficient area has produced a response to copper in all three cases.

The establishment of a soil physics laboratory was commenced in the latter part of the year under the direction of an American Soil Physicist sent to us by the International Co-operation Administration of the U.S.A. The installation of apparatus for laboratory soil moisture testing has enabled a start to be made with water consumption experiments on irrigated crops.

In the Plant Pathology section Bacterial Wilt of potatoes caused by *Pseudomonas solanacearum* was the subject of detailed surveys as it is a threat to the whole potato industry. Smut (*Ustilago scitaminea*) on Sugar cane has increased in severity and advice on control has been repeatedly tendered to growers with little effect. Seed dressing trial work was continued.

In the Plant Breeding section the struggle to keep the wheat crop going in the face of stem rust attack is exemplified by the fact that 47 varieties have been released over the past ten years. It has been estimated that 70 per cent of the 1960 planted acreage was covered by varieties released in the last four years.

The synthetic maize bred at Kitale is proving itself under conditions of good fertility. At Machakos the quick variety Taboran is proving its worth and it has been established that it is a more reliable yielder in the drier areas. Trials have also shown that this variety in producing a crop depletes the soil moisture to a lesser extent than local white maize and this can also have a big effect on the yield of the subsequent crop.

In Coffee Research Leaf Rust (*Hemileia vastatrix*) has been recorded from Robusta Coffee for the first time in Kenya. A study of the basic principles affecting the integration of insecticidal and biological control of Leaf miner *Leucoptera* spp. was started by Professor Bess who is here on a Fulbright Scholarship for nine months at the Coffee Research Station. The wide range of work conducted by the Coffee Research team is fully reported in the text.

The work of the Coffee Berry Disease Research Unit under the able leadership of Dr. F. J. Nutman also takes in Leaf Rust (*Hemileia vastratrix*). The principal laboratory results now confirmed by extensive field studies are that *Hemileia* spores are dispersed over very short distances by rain and not over long distances by wind; that infection follows more closely the pattern of a water-borne pathogen than that of a typical rust in that a high inoculum-density is required; and that while dry spores can remain viable for a long time they become highly susceptible to desiccation after being wetted for a few minutes only. Other studies are in progress.

The Grassland Research Team covers a very wide field with substations at Molo in the Highlands and Marigat and Katumani in the drier areas. In the animal agronomy work there are indications at Kitale that the assumption that the grass rather than the animal was the limiting factor to higher milk production there is not necessarily the case. Results seem to indicate that some judicious culling in commercial herds would help to raise milk production per acre substantially.

In the Chemistry Laboratory at Kitale substantial progress has been made in studies on the digestibility and nutritive value of ruminant and pig feeds. It is now possible to predict the nutritive values of these feeds from knowledge of the amount of crude protein which they contain in their dry matter.

The wide range of horticultural crops which are under investigation by the section has resulted in the collection of a vast amount of grower information which is to be written up.

Fertilizer experiments on pyrethrum over a range of soil types have again shown that the main responses are to be derived from phosphatic fertilizers. Irrigation to supplement the scanty rains during the year at Molo resulted in a better establishment of the plants and higher yields. The rotation trial started in 1947 has now demonstrated that continuous cultivation of pyrethrum on the same land will result in diminished yields.

In Sisal, studies on nursery techniques are indicating the value of a so-called "smother nursery" to let weak plants and late starters reveal themselves before planting into the nursery proper in the hope of finally establishing more even plants from the nurseries.

No significant developments have taken place in irrigation research since the last report. Studies of beef production from irrigated grass are continuing at Perkerra and much attention has been given to the onion crop as a source of cash for these schemes.

On the general investigation stations in the African areas the field of work has been extensive following the pattern established in previous years. Particular attention is focused at present on the drier areas where studies of the rainfall pattern retention of moisture in the soil and the effect of crop rotation are yielding information of exceptional interest and value.

With regard to the mixed farming areas in the Highlands the work on cattle, pigs and sheep reported in the text has been of especial interest. Attention has been given to possible alternative crops in particular bean varieties, geranium for oil, safflower and soya beans.

The research advisory committees have continued to play an important part in effecting liaison between producers and research officers and ensuring that attention is devoted to the practical problems of producers.

It remains to thank all those who have helped forward the work of the Research Division during the year, not least the officers of the Division.

B. C. WILLS,
for Ag. Chief Research Officer.

6th June, 1961.

ANNUAL REPORT OF THE SENIOR ENTOMOLOGIST, 1960

Entomologists were stationed at Kibos (Nyanza Province) and Nakuru (Rift Valley). In the Coast Province the entomological laboratory was moved from Matuga to the new experimental station at Mtwapa. The Stored Products Entomologist was based on Kilindini while the Maize Marketing Board officers worked from the Scott Agricultural Laboratories. The Coccid Taxonomist, Advisory and Plant Protection Services were also based there.

The Coffee entomological team, now with two entomologists, submits its annual report separately.

Plant Protection Services

Small defects and shortcomings in the schedule of the Standing Technical Committee on Plant Imports and Exports have been rectified and this has resulted in much smoother operation of the import regulations. Legal Notice No. 634 of December 1960 brings our legislation into agreement with the Schedule and it lists in addition commodities which do not require an import permit.

A booklet giving further details of the schedule has been compiled and it is hoped to publish it shortly. This should be a great help to importers.

Importation of Plants

Parcels inspected through the Post Office totalled 1,039, an increase of 198 over 1959.

Plant Importation Permits issued totalled 1,282 as compared with 1,511 in 1959. Air freight consignments at 233 were in excess of the 1959 figure of 217.

Export of Plant Material

Phytosanitary certificates for export consignments totalled 318 showing an increase of 19 over 1959, 32 over 1958 and 89 over 1957 figures.

Fumigations

Hydrocyanic acid gas fumigations totalled 39 while 7 methyl bromide fumigations were carried out.

Insects Intercepted

Cydia pomonella on apple fruits from Switzerland.

Aonidiella aurantii on oranges from South Africa.

Aspidiotus destructor and *Furcaspis* sp. on oranges from Israel.

In addition a 2 oz. block of gold was found in bird seed.

Once again it is a pleasure to record the helpful co-operation of the staff of Customs and Excise, the General Post Office and the East African Airways Corporation.

Stored Products

Two meetings were held of the Pest Infestation of Stored Products Committee. This has extended its membership and is now attended by representatives from the Maize Marketing Board, the Kenya Farmers' Association, the Nyanza Province Marketing Board, and the Central Province Marketing Board.

With the emphasis of the Maize Marketing Board on sales rather than storage there is less need for entomological work on maize but there is still the necessity for further knowledge of wheat pests. Propaganda on farm storage is also essential and it is intended to obtain staff to work on these two points. With this object in view visits were made to the U.K. Pest Infestation Laboratory by the Chief Research Officer and the Senior Entomologist.

Mr. Burns Brown, Principal Scientific Officer, Fumigant Section of the Pest Infestation Laboratory visited Kenya to advise on methyl bromide fumigation. Visits from other experts from Slough may be arranged to give advice on local storage pests problems.

W. M. Graham and S. P. L. Kockum of the Maize Marketing Board report as follows:—

As a continuation of the experimental programme directed towards the provision of a "seal" against insect reinfestation of large stacks of fumigated produce, three stacks of maize in Nairobi, and two stacks at Mombasa, were covered with polyethylene sheeting. The numbers of bags in these five stacks were, sixteen, fourteen, four, twelve and thirteen thousand, respectively. Most of the sheets employed were of inferior quality and generally, no effective seal was obtained. The 16,000 bag stack of maize was heavily infested by primary and secondary storage pests and was heating. Temperatures in the vicinity of 40° C. (104° F.) were recorded several layers below the top of the stack. As a consequence of the heavy but uneven insect infestation the heating of the stack was uneven and moisture translocation had occurred; on the upper surface of topmost layer of bags the moisture content was about eighteen per cent, in the bottom of the same layer of bags the moisture content was only fourteen to fifteen per cent, and near the bottom of the stack the moisture content of the maize was under twelve per cent. Mould was apparent on the top when the maize was covered with polyethylene (five-thousandths of an inch thick) sheets, and fumigated with methyl bromide. The spread of the mould over the top of the stack was rapid during the following ten days. The sheets were finally removed for fear of large losses, and it was discovered that already most of the mould was dead, the stack had cooled, and the moisture was moving down from the upper layer. The indication was that even when given such extreme and rare cases of an advanced infestation, and general deterioration of grain, the polyethylene sheeting technique could be made to work effectively. The results of two controlled stack experiments employing plastic sheets (discussed in earlier reports) have been prepared for publication. On the basis of all the results in this programme of work polyethylene sheets have been ordered by two of Kenya's storage organizations, and over 100,000 bags of produce should be covered during 1961.

A large experiment employing two nine by nine Latin squares (162 bags of maize of 200 pounds each) was completed at Kisumu. The experiment compared three levels of admixing with lindane dust, three levels of admixing with malathion dust, admixture of diatomite alone, and kaolin alone, and an untreated control. The results were very clear-cut and showed the superiority of malathion dust to lindane dusts as a means of controlling the secondary storage pests *Tribolium castaneum* and *Oryzaephilus surinamensis*. Since the fumigation with methyl bromide gas has become widely accepted, it is the secondary pests, rather than the primary pest *Sitophilus oryzae* (the weevil), which have assumed the role of major pests in much of Kenya's storage. It was therefore recommended by the Pest Infestation of Stored Products Committee that as from 1st Jan. 1961 the dust formulation to be generally employed would be 0·7 per cent malathion (to be used at a rate of 4 oz. of dust per 200-pound bag of produce). With produce which cannot have a dust admixed, layer dusting with a malathion dust (lindane dust in the case of uninfested wheat) is to be continued. The results of the admixing experiment have been prepared for publication.

A simple trap for *Tribolium castaneum* was developed and was proved effective when employed in the admixing experiment described above. The trap exploits the habit of *T. castaneum* adults to climb daily to the highest accessible point and take flight. The *Tribolium* are led to a position from which they fall into a glass vial. Since the adults cannot walk on a glass surface they are efficiently trapped. In one experiment a sample bag was screened on a bag sieve and several pounds of dust were recovered. During a 24-hour period of trapping over 8,000 living *T. castaneum* were recovered from the dust; it is estimated from other results that fewer than 100 living beetles were left untrapped.

The *Tribolium* trap has also been used to collect records of *Tribolium* on the upper surface of a large stack of maize. Using 60 traps data has been collected twice weekly for over four months (trapping was done from 2 p.m. to 4 p.m.). It is difficult to say whether the numbers trapped reflect the actual *Tribolium* population, or only the rhythm of activity of the beetles, but the results have shown the technique to be of extreme value, and the work is being continued. Details of the construction and use of the trap are being prepared for publication.

In addition to the collecting of data on *Tribolium* numbers, there has been an effort to obtain further refinements in sampling technique associated with stack and bag experiments. Gross losses in storage have been divided into several categories; weight loss due to drying, weight loss due to insect and mould metabolism, and weight loss related to the increased amount of dust (mainly insect excreta). Related to this line of work has been an analysis of data collected over the past twelve years, which has provided a fairly precise description of the losses caused by *S. oryzae*.

Mr. Ashman, Stored Products Entomologist, reports as follows:—

1. Insecticide trials using 0·04 per cent lindane and diatomite dust and 2 per cent malathion dust carried out at Mtwapa gave the following results after 8 months' storage:—

(i) Lindane admixed at 16 oz. of 0·04 per cent dust per 200 lb. of maize gave no protection against *Sitophilus oryzae*, *Tribolium castaneum* and *Ephestia cautella*.

(ii) Malathion at 1¼ oz. of 2 per cent dust per 200 lb. of maize gave no practical protection.

(iii) Lindane at 16 oz. of 0·04 per cent dust per 200 lb. admixed, with 3 oz. of 2 per cent malathion applied externally gave a high degree of protection.

(iv) Malathion at 1¼ oz. of 2 per cent dust admixed with 200 lb. with an external dusting of 3 oz. of 2 per cent malathion dust gave a complete protection.

None of the treatments were fumigated initially, all maize came into store infested from the field. Treatments (i) and (ii) had to be fumigated because of heavy damage after 3-4 months. Observations carried out at Shimba Hills and Kilifi showed that 0·04 per cent lindane dust applied at 8 oz. per 200 lb. of maize gave no protection, populations of up to 12,000 *Sitophilus oryzae* per 200 lb. were found after 3-4 months storage.

2. Malathion wettable powder/lindane diatomite dust experiment results so far obtained are as follows:—

(i) Lindane 1 per cent dust in a diatomite base applied, before fumigation, externally to 200 lb. sacks of maize at 3 oz. per sack, and subsequently after one month at 15 oz. per stack surface (10 sacks per stack) gave no better control of *Tribolium castaneum* than the untreated stacks.

(ii) Lindane 1 per cent dust in a diatomite base at twice the level of (i) above gave no better control of *Tribolium castaneum* than the untreated stacks.

(iii) Applications of malathion 25 per cent wettable powder at 150 mg. and 100 mg. per sq. ft. applied just before fumigation and then once weekly and once fortnightly after fumigation, gave a good control of *Tribolium castaneum*, significantly better than the untreated stacks.

(iv) A good control of *T. castaneum* was obtained, significantly better than the untreated stacks, by spraying 25 per cent malathion wettable powder at 100 mg. and 150 mg./sq. ft. initially prior to fumigation and thereafter every three weeks over a six-month period.

(v) Chemical analyses showed that the heavy applications made in (iii) and (iv) above did not penetrate rapidly into the maize through the sacking material.

3. Wheat Store Inspection and advisory work continued and as a result of increased efficiency of storekeepers, the stores at Ol Kalou, Naivasha and Thomson's Falls were free of all insect pests after 6 to 8 months' storage. *Sitophilus sasakii* (Tak) previously referred to as *Calandra oryzae* (L) small strain, is now identified as a distinct species. In farm and store surveys carried out in 1959, *S. sasakii* was found only in wheat and *Sitophilus* (*Calandra*) *oryzae* (L) was found only in maize. The two species do not inter-breed and *S. sasakii* breeds more rapidly at normal temperature ranges than *S. oryzae*. The most frequently recorded secondary pest in wheat was *Oryzaephilus surinamensis*. There is no evidence to show that *S. sasakii* becomes established in the wheat field.

4. *Silo Storage.*—A plywood silo capacity 20 tons, with a concrete plinth and canvas roof has been on trial at Mtwapa for approximately 16 months. Tada sorghum treated with 1¼ oz. of 2 per cent malathion dust for each 200 lb. received virtually complete protection for 8 months. The grain was infested with *S. oryzae*, *Araecerus fasciculatus* and *Sitotroga cerealella* before storage.

5. *Phostoxin.*—Three fumigations were conducted using Phostoxin tablets. A small consignment of Pakistan rice was fumigated under plastic sheets, using 1 tablet of Phostoxin per bag (200 lb.) for three days. A 100 per cent kill of late instar *Trogoderma granarium* larvae test insects placed inside the bags of rice was obtained.

A new method of Phostoxin fumigation was developed using metal pipes built into a stack of maize. A 100 per cent kill of all stages of *Sitophilus oryzae*, *Sitophilus sasakii* and *Spermophagus subfasciatus* was obtained using 1 tablet per 200 lb. bag for five days.

6. *Methyl bromide Fumigation.*—A 100 per cent kill of mature *Trogoderma granarium* larvae was obtained in cotton bales treated at 3 lb. and 4 lb. per 1,000 cu. ft. for 24 hours under gas-proof sheets. The test insects were baled into the centre of each bale protected in steel tubes. The control insects pressed into bales which were unfumigated; all survived.

7. The following new records of stored products pests are recorded for Kenya:—

(i) *Bruchus lentis*, Coleoptera, Bruchidae—found on lentils from Lebanon at Mombasa.

(ii) *Necrobia ruficollis*, Coleoptera, Cleridae, found on bones at Mombasa.

(iii) *Sitophilus sasakii*, Coleoptera, Curculionidae, found in wheat up-country in Kenya.

(iv) *Anthrenus verbasci*, Coleoptera, Dermestidae, found in a woollen carpet at Mombasa.

(v) *Ptinus tectus*, Coleoptera, Ptinidae—Kenya wheat.

(vi) *Ptinus fur*, Coleoptera, Ptinidae—in Kenya wheat.

(vii) *Typhaea stercorea*, Coleoptera, Mycetaeidae. Food residues Mombasa and rice Mombasa.

(viii) *Ephestia kuhniella*, Lepidoptera, Pyralinae. Flour mill Eldoret.

(ix) *Pyralis farinalis*, Lepidoptera, Pyralinae. Ship's hold Mombasa.

(x) *Endrosis sarcitrella*, Lepidoptera, Oecophoridae. Naivasha wheat store.

8. Malathion and lindane/D.D.T. wettable powder sprays were used as follows on two large stacks of maize (12,000 bags) at Mombasa.

A week after fumigation, one stack was sprayed externally with 25 per cent malathion wettable powder at 14 oz. per 1½ gallons of water per 1,000 sq. ft. and then a further eight times at fortnightly intervals at this rate of application. The malathion residues found after 9 consecutive sprayings were as follows:—

First inch of maize inside the sack, i.e. in contact with sacking material	*Maize from centre of the sack*
Mean 9·3 p.p.m.	Mean 1·13 p.p.m.

The other stack was sprayed with a lindane/D.D.T. wettable powder comprising 2 parts 50 per cent D.D.T., 1 part 50 per cent lindane at 9 oz. in 1½ gallons of water per 1,000 sq. ft. The spraying application was carried out as outlined for malathion above:—

Spray	*First inch of maize inside sack*	*Maize from centre of sack*
D.D.T.	Mean 19·1 p.p.m.	Mean 3·2 p.p.m.
Lindane	Mean 3·9 p.p.m.	Mean 0·8 p.p.m.

Even heavy applications of wettable powder applied externally to sack surfaces do not penetrate rapidly on to the maize inside.

Observations of insect infestations occurring in produce at Mombasa suggest that three commodities, i.e. Maize from Tanganyika, Beans from Tanganyika and Uganda and Cottonseed Cake, mainly from Uganda, are the chief sources of cross-infestation to railway trucks, godowns, port transit sheds and ships.

Insect infestation in imported Australian wheat has been less overall during this year than in 1959.

Field Pests

Mr. Bullock reports as follows from Rift Valley Province:—

Seed dressing work was greatly reduced this year, only three small experiments on the barley fly (*H. arambourgi*) and two observation trials on Black Wheat Beetle (*Heteronychus* spp.) being performed. Work on pyrethrum leaf thrips (*Thrips nigripilosus*) continued, although lack of reports and the impracticability of planting several experiments due to drought greatly reduced the planned programme. *Thrips tabaci* on both pyrethrum and onions were experimented upon. *Nematocerus* sp. took up a considerable portion of the programme, since an infestation at the Njoro Plant Breeding Station offered considerable opportunities for research.

Barley Fly.—In two trials, dieldrin seed dressing applied at a rate of 3·5 oz. active insecticide per 100 lb. seed gave as good a control as 5 oz. per 100 lb. This confirms the experience of 1959, and the recommended rate of application has been reduced accordingly.

Heptachlor at a rate of 4·8 oz. per 100 lb. seed gave good control and a recommendation for this insecticide has been issued.

Nematocerus sp.

1. *Adults.*—Observation trials and commercial applications have shown that D.D.T. sprays and dusts and y B.H.C. baits effectively control this pest. Dieldrin appears to be less satisfactory whilst Sevin had no effect when applied as spray containing 8 oz. actual per acre.

2. *Ova.*—Laboratory tests indicated that y B.H.C. and to a lesser degree D.D.T. greatly reduced hatching, but subsequent field tests suggest that this is a fumigant effect due to the ova being confined in a small space. Ova collected soon after spraying show heavy mortality but not those collected eight days later. (The egg stage lasts 12–15 days and hence a fair proportion of egg masses collected seven days later would have received the treatment.)

3. *Larvae.*—Laboratory tests showed that newly hatched larvae were very tolerant of insecticides especially the cyclodeine hydrocarbons. Those tested were Baytex, y B.H.C., D.D.T., heptachlor, dieldrin, endrin, toxaphene, malathion, diazinon, chlordane, Rogor, Metasystox, Sevin, Lead arsenate, and pyrethrum, and of these only y B.H.C. and Baytex showed any reasonable promise.

A field test planted in September showed considerable phytotoxicity in those y B.H.C. treatments applied to the seed but where a y B.H.C. in fertilizer mixture was used germination was good and a significantly higher production of ears occurred than on the control.

4. *Observations on an infestation.*—Some two months was spent examining an infestation of larvae on the Plant Breeding Station, Njoro. The main conclusions drawn from this work were that:—

(1) Fifteen 4″ Core samples gave a valid estimate of the population in an area (coefficient of variance 12–15 per cent) with populations of ca. 4·0 million per acre and over.

(2) Larvae tend to congregate in the rows in row crops even where a heavy weed growth occurs.

(3) Larvae occur in grass leys, maize, wheat, oats and barley, but appear to do best in the last named crop.

(4) Populations tend to be lower in old leys.

(5) Neither dieldrin nor aldrin have any effect on populations.

5. *Parasites and Predators.*—Examination of egg masses from Ol Joro Orok, North Kinangop and Naro Moru has revealed the presence of a hymenopterous larva feeding on the ova in the first two areas whilst none were found in the Naro Moru collection.

Three other species of Hymenoptera were bred from egg masses, of which at least one was an oval endo-parasite.

A large Cyclorrhaphan larva was observed feeding on a larva on one occasion but its incidence as revealed by soil sampling was very low.

Black Wheat Beetle.—Two observation trials using a heptachlor seed dressing against this beetle indicated that good control could be obtained with applications of 2 oz. actual for 100 lb. seed.

Pyrethrum Leaf Thrips.—This has now been identified as *Thrips nigropilosus* and not *Thrips tabaci* as was previously reported. *T. nigropilosus* is the only species occurring in numbers on the leaves and has never been recorded in the flowers (cf. below). A number of apparent alternative hosts including *Bidens pilosa* and *Galinsoga parviflora* have been recorded in association with infestations on pyrethrum and if these are true alternative hosts, as seems likely from the presence of larvae and adults, the possibility of preventing infestations by removal of natural hosts is remote.

Observations on chemical control show that both D.D.T. and Metasystox continue to give effective control when sprayers are used correctly.

Experiments have been greatly handicapped by dry weather and several plantings have been delayed until 1961.

Pyrethrum Flower Thrips (*Thrips tabaci*, *Taeniothrips* sp. *Microcephalothrips* sp.).—Damage to pyrethrum grown for seed caused considerable concern towards the end of the year. In a trial at Molo, dieldrin at 3·6 and 7·2 oz. actual per acre gave the best control, Sevin (7·5 and 15 oz. actual), Metasystox (5 oz. actual) and MC 47 (10 oz. of formulation) gave some control whilst y B.H.C. (4 oz. actual) and D.D.T. (15 oz. actual) were ineffective.

Other Pests.—A pioneer hydroponics scheme at Nakuru, in which tomatoes and cucumbers are being grown, has experienced considerable pest problems. On the tomatoes, Aleurodids and Tetranychids have caused heavy losses but are now being successfully controlled with Metasystox prior to flowering and subsequently with D.D.T. and Tedion respectively. On the cucumbers, pyrethrum is used as a routine spray against aphids, whilst malathion poison bait is used to control *Dacus* spp.

An observation trial on control of *Busseola fusca* on maize indicated that pyrethrum marc (i.e. the vegetable residue from extraction containing 0·1–0·08 per cent pyrethrins) has possibilities for control.

Baiting of cutworm (*Euxoa* and *Agrotis* spp.) with aldrin-maize meal mixture (1·400) gave a measure of control in observation trials.

Control of *Gonocephalum* (formerly *Dasus simplex*) was achieved with baits of 2·6 per cent y B.H.C. in bran or pyrethrum marc (4·96) whilst aerial applications of D.D.T. (15 oz. actual) and dieldrin (7·2 oz. actual) per acre gave reasonable reductions in populations.

Mr. La Croix reports on work carried out in the Coast Province by Messrs. Wheatley and Bond as follows:—

Field work on the Coreid Bug, *Pseudotheraptus wayi*, closed down but a laboratory stock of the bug has been retained for the rearing of the egg parasite, *Ooencyrtus*, which has been supplied to Zanzibar.

In a cotton trial at Msabaha 3:10:0 cotton dust was compared with D.D.T./B.H.C. sprays in 8 gallons and 100 gallons of water. The sprayed treatments gave no significant increase over the dust treatment.

In another trial 3:10:0 cotton dust (containing 3 per cent gamma B.H.C.) was compared with a 5:10:0 dust (containing 5 per cent crude B.H.C.) and the more expensive dust containing 3 per cent gamma B.H.C. gave a highly significant increase.

A trial sprayed with endrin at weekly intervals gave a yield increase of nearly 35 per cent but the amount of grade A cotton increased by 127 per cent.

At Galole a spray of 6 pints per acre of 25 per cent D.D.T. gave the best yield and most A grade cotton, and was better than 2 pints of 19·5 per cent endrin emulsifiable concentrate. A spray of 3 pints of 25 per cent D.D.T. and 1 pint of 20 per cent gamma B.H.C. was the third best treatment. These were all applied in 100 gallons of water, five times at ten-day intervals.

Less satisfactory treatments, giving an increase of about 30 per cent of Grade A cotton were 1 pint of 19·5 per cent endrin, 3 pints of 25 per cent D.D.T. and 2 pints of 18·6 per cent dieldrin. Three pints of 50 per cent malathion was little better than no treatment.

Jassid counts on three varieties of cotton averaged as follows:—

UK 51—5, UK 58—8, IL 58—25.

Residues of insecticides were tested against *Dysdercus cardinalis* and showed that 1 gram of 3:10:0 per plant was ineffective after 3 days. Two grams of this dust was effective up to 4 to 8 days.

Mr. Davidson reports from Nyanza Province as follows:—

Cotton Pests.—When all results are available they will be published fully in the Empire Cotton Growing Corporation Progress Report.

Studies at Kibos on stainers (*Dysdercus* spp.) showed that numbers increased steadily by breeding on wild Malvales, principally *Hibiscus* and *Abutilon* spp., during the main rains from March to May. Few stainers were found on November-planted cotton adjacent to the wild hosts, although it carried abundant green bolls. During this period the incidence of the Tachinid parasite *Bogosiella fasciata*, as measured by the presence of its eggs on adults of *D. nigrofasciatus* and *D. superstitiosus*, increased from 6·5 per cent in late March to 90 per cent in mid-May. During June, numbers of adult stainers on wild Malvales decreased, but adults and nymphs increased on a red-grained sorghum variety grown at Kibos. Surveys in sorghum fields within a three-mile radius of Kibos, which were nearly all planted with white or brown-grained varieties, revealed very few adult stainers and no nymphs. Immigration of stainers into March-planted cotton during June and July was found to correspond to the ripening of the sorghum crop, and the incidence of Tachinid parasites was found to be similar on the adults on sorghum and on the immigrants on the cotton. By early July adults and nymphs were almost completely absent from wild Malvales. Populations of adult stainers on cotton decreased from late July to mid-August, then increased again with the maturation of adults bred in the cotton crop, to a maximum of 6,000 adult stainers per acre in late August. Incidence of Tachinid parasitism on adult stainers in cotton fell from 35 per cent in July to under 5 per cent in October and November.

Methods of trapping and counting cotton pests were studied. Cylindrical yellow sticky traps covered with removable polythene film sheets bearing adhesive were found to be simple to make and operate, and gave larger catches of Mirids, Jassids and alate Aphids than did flat traps of the same surface area. The standard method of counting stainers on cotton was tested by repeated counting and it was found that only 60 per cent to 75 per cent of the stainers present were observed in a single count. Plastic sponge soaked in cotton seed oil was found to attract stainer adults and nymphs, but attempts to devise a trap based on this were unsuccessful.

Blanket spraying of 8 oz. D.D.T. and 5 oz. gamma B.H.C. per acre weekly with motorized knapsack sprayers suppressed all major pests. Addition of diazinon to one spraying during early July eliminated an attack of aphids. This technique was used to protect agronomy experiments and variety trials.

A trial at Kibos with dusts containing 3 per cent gamma B.H.C. combined with 10 per cent, 5 per cent and 2½ per cent D.D.T. showed that the 3:10:0 and 3:5:0 dusts were equally effective in control of stainers and bollworms, and superior to 3:2½:0. Yield results confirmed that 3:5:0 is as effective as 3:10:0, and consequently 3:5:0 has been recommended for future use by peasant farmers. In district plots in South Nyanza, 3:10:0 at 60 lb./acre was found to be as effective as at 80 lb./acre; dusting beginning 10 weeks after planting gave better yields than that beginning 14 weeks after planting.

At Busia, a repeat of the 1959 experiment confirmed the previous results that protection from the 9th to the 14th week after planting gave lower yields than protection from the 14th to the 18th week, and that during these periods, six applications of ½ lb. D.D.T. per acre at 6-day intervals gave higher yields than 4 applications of 1 lb. at 10-day intervals. In the Malakisi area of Elgon Nyanza standard 4 x 1 lb. D.D.T. spraying on district plots gave good control of Lygus, Helopeltis and Spiny Bollworm and yields double those of the corresponding control plots were frequently obtained. At Homa Bay, a preliminary trial with Sevin indicated that it is as effective as D.D.T./B.H.C. against the major pests.

Coffee Pests.—In nurseries in the Kisii area the incidence of the root scale *Saissetia coffeae* and of "stem-pitting/bottling" symptoms in seedlings were greatly reduced. It is not possible to assess how much this was due to the treatments of soil and foliage with dieldrin and Metasystox respectively, and how much to the considerable improvements in seedling bed preparation and management. The recommended dipping in 5 per cent white oil was not carried out at seedling issue.

Hypothonemus (*Stephanoderes*) *hampei* on Robusta coffee in Ukwala was controlled by B.H.C. sprays. On one shamba the spraying induced an attack of *Habrochila.*

A severe attack of *Epicampoptera andersoni* on old coffee at Sotik was controlled by D.D.T. applied at 1 lb./acre with motorized knapsack sprayers, after malathion had failed to give control.

Other Pests.—Outbreaks of tea root weevil, *Aperitmetus brunneus*, and pyrethrum thrips were reported from the Kisii area. A few small swarms of desert locust, *Schistocerca gregaria*, entered South Nyanza during February and penetrated as far as Lumbwa, doing only slight damage. No specimens were found of *Trogoderma granarium*, which was thought likely to enter the Province from Tanganyika.

Biological Control

Dr. Simmonds, Director of the Commonwealth Institute of Biological Control visited Kenya in March and April to discuss further use of biological control against local pests and weeds. As the establishment of a sub-station in Nairobi, or Uganda was discussed, it was decided to leave new introductions until plans had been finalized. During the year attempts were made to spread established species still further. The Cochineal Insect, now identified as *Dactylopius indicus* has spread slowly in the Naivasha area but has done well in Nairobi and at Karungu in Nyanza. Unfortunately it appears to have died out at Mariakani. At the Scott Agricultural Laboratories it has completely wiped out plants of three kinds of prickly pear.

The Seed fly of Lantana, *Ophiomyia lantanae*, is now widespread through the territory but the Lacebug *Teleonemia scrupulosa* does little more than maintain itself outside the Protectorate. Rearing of the ladybird *Hyperaspis jocosa* continued on a reduced scale and difficulty was experienced in obtaining *Orthezia insignis* on which to feed it.

A survey of the insect pests of *Striga hermonthica* was carried out in Nyanza with the possibility of biological control of this weed in mind.

The parasite, *Eretmocerus serius*, of the Citrus Black Fly, is now well established at Diani and Matuga in the Coast Province.

Systematic Study of Coccidae

Mr. De Lotto visited London in May where he studied material from Africa deposited in the British Museum (Natural History) and the Commonwealth Institute of Entomology.

A survey of the black and brown scales of East Africa was begun and further material is being collected from Africa South of the Sahara for critical examination of morphological variations.

Routine identifications of African Coccids continued.

Publications

Bullock, J. A.—

"The Shiny Cereal Weevil and Legless Grub", *Kenya Farmer*, July 1960.

"Greenfly on Cereals", *Kenya Farmer*, August 1960.

De Lotto, G.—

"The Green Scale of Coffee in Africa South of the Sahara", *Bull. Ent. Res.* 1951.

Wheatley, P. E.—

"Insect Pests in the Coast Province of Kenya. 1—Mango", *E.A. Ag. & For. J.* XXVI No. 2.

Bullock, J. A.—

Advisory leaflets were produced and notes were published on the Pyrethrum Page of the *Kenya Farmer* for November and December 1960. Also a short report for inclusion in the Annual Report of the Pyrethrum Board of Kenya, 1959–60.

A review of the work covering the period 1954–59 was compiled for inclusion in the Report of the Seventh Commonwealth Entomological Conference 1960.

Acknowledgements

The help of the Commonwealth Institute of Entomology in the identification of insects and on publications is acknowledged with thanks.

J. F. GRAHAM,
Senior Entomologist.

ANNUAL REPORT OF THE SENIOR PLANT PATHOLOGIST, 1960

The Advisory Laboratory.—Due to the dry year, disease incidence was generally low and only 350 plant disease specimens were submitted for diagnosis compared with 638 during 1959. "Gummosis" (*Cladosporium cucumerinum*) was recorded on cucumbers for the first time since 1936 and *Mycosphaerella melonis* caused considerable damage to various cucurbits. *Dossonsiopsis nympheae* was recorded on *Nymphea capensis* for the first time.

Bacterial Wilt (*Pseudomonas solanacearum*) of Potatoes

Surveys in agricultural areas of Central Province and Forest Stations of Eastern Rift have shown that bacterial wilt of potatoes is now widespread. Nyeri and Kiambu districts were surveyed in detail and it was found that these districts respectively had 75 per cent and 30 per cent of their potato crops diseased. Bacterial wilt is regarded as a disease of soils which is spread by diseased seed tubers. Loss of land for potato cultivation is more important than loss of crop from diseases such as blight (*Phytophthora infestans*) and bacterial wilt constitutes a serious threat to the potato industry. It is quite the most important disease of potatoes in Kenya. Control of bacterial wilt will depend on the production and regular use of disease-free seed tubers and there is a possibility of developing resistant varieties.

Sugar Cane Diseases

Smut (*Ustilago scitaminea*) which first appeared in Kenya in 1956 is increasing in severity and seems to be building up in cane stocks. Cane growers have not yet established sett nurseries derived from heat-treated cane and, so long as infested setts continue to be sown, smut is likely to increase in importance. Similarly, ratoon stunting disease is not being controlled and it is believed regular heat-treatment of planting material will lead to considerable increases in yield.

The sugar cane museum at Kisumu has been abandoned as a variety collection and is now being maintained as a disease collection and disease-susceptibility testing ground. An open quarantine has been established at Scott Laboratories to take cane coming from the closed quarantine at the East African Agricultural and Forestry Research Organization.

Geraniums

Severe losses in geranium grown for oil have resulted from a species of *Graphium*. Pathogenicity tests have shown that the fungus will not invade tissues of healthy plants but it can be damaging on newly planted cuttings and on established plants which are unhealthy due to adverse environmental factors. In a trial at Molo, cuttings which were dipped in 0·5 per cent Captan had a higher survival rate than untreated cuttings.

Passion Fruit

Vines of the supposedly woodiness disease-resistant varieties of passion fruit (described in the 1959 report) are being multiplied for field testing. There are now 44 established vines, and seedlings for a further 60.

Segregation is occurring and morphological differences between individual vines are clearly visible.

Fungicide Investigations

An experiment to test the effect of fungicidal seed dressings on the longevity of coffee seed was started. Four batches of coffee were dressed with captan, organo-mercurial, thiram and Spergon fungicides respectively and half of each batch was treated with wood ash in the normal way. Samples from each treatment are being tested each month. The experiment is to run for twelve months.

Trials using Captan, Thiram, an organo-mercurial and Spergon fungicides as seed dressings were conducted on peas, beans and maize in several localities. None of the bean or maize trials produced significant results but, on peas, Captan used at a rate of 1,250 p.p.m. (4 oz. of Captan per 100 lb. of seed) gave significant increases in germination and yield.

Trials to investigate the effects of fungicidal spraying of wheat to control stem rust (*Puccinia graminis*) were conducted at Mweiga and Ol Joro Orok using air blast, knapsack sprayers to simulate aerial spraying. The fungicides used were "Zineb" and the Rohm and Haas nickel compound "03818–B", both applied at a rate of 2 lb. per acre. The incidence of rust at Mweiga was too low to permit useful results and the Ol Joro Orok trials had not been completed by the end of the year.

Nematode Investigations

A preliminary trial was conducted to estimate the loss of yield in pyrethrum due to root-knot nematodes. The segregation that occurs amongst pyrethrum seedlings makes a trial of this nature difficult as clonal material which can be guaranteed free from nematodes is unavailable. This first trial consequently aims at a determination of the statistical requirements in a trial using heterozygous seedling material. There are 100 selected seedlings being grown individually in pots, half of which have been inoculated with *Meloidogyne hapla*. Visual observations indicate that there is a slight retardation of inoculated plants which, however, seem to have more prolific root systems.

Pot tests on four nematode-resistant tomato varieties imported from abroad showed that one variety was reasonably resistant, two were only slightly resistant and one was apparently fully susceptible when inoculated with a mixture of *Meloidogyne hapla* and *M. javanica*.

Soil fumigation trials showed that Shell DD, ethylene dibromide and methyl bromide were effective in controlling root-knot nematodes on tomatoes. Although difficult to apply, methyl bromide has the advantage of being a weed-killer.

Mycological Herbarium.—More than a hundred specimens were sent to the Commonwealth Mycological Institute for determination. Details are being published separately.

Wheat Rust.—The report of the Cereals Pathologist is included in that of the Senior Plant Breeder.

Coffee Pathology.—The report of the Coffee Pathologist is included in that of the Senior Coffee Officer.

Legume Bacteriology

Rhizobium Extended Evaluation Trials.—In order to obtain wide ranges of data, simple trials were replicated many times in numerous localities. Each trial consisted of two plots only, sown with inoculated and uninoculated seed, and recorded data of a presence or absence nature only. Three hundred trials were conducted by officers of the Department all over Kenya and involved the following legume species: *Glycine max*, *Dolichos lablab*, *Crotalaria juncea*, *Pisum sativum*, *Medicago sativa*, *Lupinus* sp., *Lotononis bainesii*, *Trifolium repens*, *T. subterraneum* and *T. semipilosum*. Results were obtained from nearly 70 per cent of the trials which provided data on the effectiveness of S.A.L. inoculant in the field, natural nodulation, nitrogen fixation, etc. Full details will be published separately.

Nitrogen-Fixation Measurement Trials.—Eleven field trials involving five legume species were conducted at Njoro, Ol Joro Orok and Scott Laboratories to measure the amount of nitrogen fixed by inoculated plants in terms of equivalent response to uninoculated controls treated with varying amounts of fertilizer nitrogen. Drought spoiled most of these trials. Results will be published separately.

Rhizobium Mortality Rates in Culture.—Culture storage experiments were conducted to determine the expiry period of S.A.L. inoculant and to explore possibilities of extending it by improved methods of storage. Preliminary results indicate that the current expiry date of ten weeks after manufacture is probably excessive unless the mortality rate is reduced. Mortality rates of sealed and unsealed cultures in deep-freeze (−25° C.) and at room temperature were compared. As was expected, the sealed frozen cultures had the lowest mortality rate. Full details will be published separately.

Inoculant Dosage Rate Investigations.—Fifty routine bacterial counts were made on standard inoculant cultures and the results were related to the numbers of seeds per pound of the legumes involved in order to determine inoculant dosage rates in terms of numbers of *Rhizobium* cells per seed. Results varied from 1,500 cells with small-seeded legumes to 30,000 cells with large-seeded legumes.

The Rhizobium Bank.—Development of the *Rhizobium* bank was continued during the year. Although primarily a collection of *Rhizobium* strains in nodules on living legumes, the bank is performing a secondary function in providing a living museum of legume species which are otherwise unavailable, notably indigenous *Trifolium* spp.

Manufacture of Inoculant.—109 orders for inoculant involving 667 units sufficient to inoculate approximately 17,000 lb. of seed were received during 1960. The analysis of orders is given in Table I.

TABLE I

Legume Species	Units Sold to Kenya Public	Units Sent to Kenya Research Stations	Units Sent Abroad	Total Units	Pounds of Seed
Lucerne group	122	123	2	247	4,940
Lupins + Serradella ..	156	33	2	191	7,220
Indigenous Trifolium spp.	23	74	8	105	2,100
Exotic Trifolium spp. ..	1	27	1	29	580
Soya	3	22	2	27	1,080
Tropical legumes ..	3	49	5	57	1,140
Misc. species	—	11	—	11	220
Total	308	339	20	667	17,280

Potato Development

Acknowledgment.—In 1960, Dr. R. M. Nattrass stopped working on potatoes and the Senior Plant Pathologist assumed responsibility for potato development. Dr. Nattrass has worked on potatoes ever since blight (*Phytophthora infestans*) first appeared in Kenya in 1941 and it is due to his efforts that the majority of potatoes now grown in Kenya are blight resistant. This is no small achievement in the field of plant disease control.

The New Programme.—The whole of potato development work has been reviewed and all aspects of it have been drawn together in a new development programme which covers policy, production and development of new varieties, seed certification, disease control, etc. In particular, the programme aims at high yields through improved disease control. The most damaging diseases, in order of importance, are bacterial wilt (*Pseudomonas solanacearum*), blight (*Phytophthora infestans*) and leaf roll virus. Bacterial wilt control measures involve the large-scale production and use of disease-free seed tubers and, possibly, the development of resistant varieties. Spraying against blight is impracticable in Kenya for a variety of reasons and blight control can only be achieved by the use of resistant varieties. Development work on new varieties has now been divided into three stages:—

Stage I. Development.—A new variety exists as a few tubers only and Stage I involves the initial bulking, testing and selection of varieties for detailed variety trials. During the long rains 105 Stage I varieties were grown in duplicated plots, one of the duplicates of each variety being sprayed for blight. Owing to the dry conditions, however, blight was rare. Nevertheless, 32 varieties were eliminated and it is expected that further selection will be made during the short rains crop due to be harvested

early in 1961. During the year, varieties were received from I.V.R.O., Wageningen and Dr. Black of the Scottish Plant Breeding Station and these are gratefully acknowledged. New varieties were also obtained from commercial sources.

Stage II. Development.—The second stage of development involves the best selections from Stage I which are later compared in detailed variety trials in various ecological zones. These trials also serve as bulking plots. Five varieties have been selected for Stage II trials.

Stage III. Development.—Final bulking of selected varieties prior to release to registered seed growers is the third and final stage of development. One variety, Roslin Eburu is now at Stage III. This variety was bred by Dr. Black (No. 1521'c(3)) at the Scottish Plant Breeding Station and it possesses all four major genes for resistance. It grows and yields well under Kenya conditions.

Gibberellic Acid Investigations.—The effect of gibberellic acid as a sprout promoter was investigated. While it undoubtedly accelerates sprout formation, this chemical had adverse effects on the crop. Investigations are continuing and details will be published separately.

Seed Testing

During 1960, 2,616 samples of cereal, grass, vegetables and flower seeds were tested for purity and germination. 79 seed specimens were identified and several additions were made to the reference collection. An experiment was started to compare the mortality rates of various seeds under Coast conditions compared with Nairobi using paper envelopes and vacuum sealed tins as storage containers.

Publications

1. "Notes on Kenya Agriculture—VIII: Important Plant Diseases", by R. A. Robinson, *East African Agricultural Journal*, Vol. XXV, No. 3, pp. 131–146.

2. "Correct Seed Dressing Routine Reduces Loss from Barley Leaf Diseases", by E. Hainsworth, *Field and Farm*, March 1960.

R. A. ROBINSON,
Acting Senior Plant Pathologist.

ANNUAL REPORT OF THE SENIOR SOIL CHEMIST, 1960

Surveys

(F. W. Collier)

The Soil Survey of Kenya series GSGS 4786 Sheet No. 119/1 which covers the Solai area was continued and in all about 140,000 acres were covered before the needs of the Ministry of Works Hydrology Team investigating the water resources of the Uaso Nyiro River system necessitated the diversion of survey activities to the Nanyuki area covered by parts of Sheets 106/1–4, 107/1 and 2, 120/2 and 121/1. Some 200,000 acres of the Uaso Nyiro catchment were then surveyed with particular reference to irrigation and of them about 20,000 were found which were considered suitable. The Solai survey continues and a report on the Nanyuki survey is in preparation.

The report on the Songhor survey and the maps to accompany it have been printed and are now on sale. They are being given a global distribution partly in token of the overseas aid which made the survey and the compilation of the report possible and partly to draw public attention to the value which can come of a properly undertaken soil survey. Considerable local public interest has been shown in the findings of the Songhor survey. Unfortunately however while the report has attracted some investment in sugar development locally, the prevailing uncertainty has prevented the major investment in factories which it was hoped would follow the survey and which at one time was on the point of taking place. The impact of the report is now feared lost.

Editing of the report on the East Koinyango survey, field work on which had been completed in 1959, was finished and the report is now with the Government Printer for publication. The accompanying maps have been prepared by the Directorate of Overseas Surveys in London for printing and are being printed in Britain.

The Fulbright reports by H. F. Heady on Range Management in East Africa and by J. L. Moomaw on Plant Ecology of the Coast Region were seen through the press.

The Solai survey covers an area which is deeply and densely faulted as a result of the eastern marginal faulting and the subsequent settling of the floor of the Gregory Rift Valley in Kenya. Consequently it is made up of a number of shelves ranging in elevation from 5,000 to 9,000 ft. and separated from one another by escarpments which range from a few tens to several hundreds of feet in height. The faulting is in a well defined north-south direction and so the land surfaces tend to be long from north to south and narrow from east to west. The underlying rocks of the highest shelves left by the faulting are phonolites and basalts of Miocene age. In the lower lying areas they are phonolites and phonolitic trachytes of Pliocene age. To the south, these last surfaces have been buried by lavas and ash showers mainly from Mt. Menengai the cauldron of which is just included on the Survey Sheet. These blanketing materials are of Pleistocene to Recent age (Geology and Ground Water Conditions in the Nakuru Area: G. J. H. McCall: Technical Report No. 3, Ministry of Works, Nairobi 1957).

The soils of the smoother ash-covered landscapes are brown to reddish brown loams with pumice or tuff usually 3 to 4 ft. below the surface. Near the Menengai rim these soils become gravelly at the surface and shallow. At the highest elevations the parent material weathers into a distinctly red subsoil. The Miocene and Pleistocene lavas have given rise to red clayey soils which tend to be more friable at the higher elevations (where climatic conditions are cool and moist and the natural vegetation is forest) than in the lower areas (where the climate is distinctly warmer and drier and the natural vegetation is a grass/bush fire climax). The faulting of the Pleistocene land surface has led to the formation of a number of shallow depressions with restricted surface drainage outlets. In these the sodium accumulation and drainage impedance have combined to lead to solodized solonetz formation. A limited area of sandy soil has developed from beach deposits of a very much larger Lake Nakuru on a long slope to the east of Mt. Menengai which eventually runs down to the present lake. In many situations the profiles are polygenetic in nature. Several ash falls

must have taken place over the Solai area and the intervals between these or between the more recent lava flows and the subsequent ash falls have been sufficiently long for appreciable soil development to have taken place before the soil forming process was stopped by the later blanketings of ash. Buried soils showing these characteristics are of widespread occurrence at Solai.

The depressed areas apart, drainage generally is good.

The Nanyuki survey is centred on an extensive shallow basin which forms part of the Laikipia Plateau and extends up the Loldaika Hills and the lower western slopes of Mount Kenya which contain the plains to the east. The basin is underlain by phonolites and trachytes which have been blanketed by thick layers of volcanic ash (Geological Report on the Nanyuki and Maralal Area: R. M. Shackleton: Report No. 11, Geological Survey of Kenya, 1946). Rainfall is comparatively low and the dry season is intense on the plains. The vegetation is an *Acacia drepanolobium—Euclea divinorum—Themeda trianda* bush/grass association (Range Management in East Africa: H. F. Heady: Department of Agriculture, Kenya, 1960). On the low ridges planosols and solodized solonetz have developed: these have grey loamy topsoils sharply breaking to dark coloured often mottled columnar structured clay subsoils.

On the flanks of these ridges the surface soils are heavier and the soils are solonetz or grumosol (black cotton) in character and may display a hummocky micro relief and a dispersion of calcium carbonate concretions throughout the profile and on the soil surface which is due to gilgai action. Gilgai situations arise from the shrinking and cracking and swelling and sealing cycles through which grumosols go during drying and wetting.

In the valley bottoms, heavy textured alluvial soils may be found and in places there are seasonal or permanent swamps. Elsewhere the rivers are fast flowing over rocky beds in eroded valleys.

The soils on the Mount Kenya foothills are formed on the phonolitic trachytes and basalts which form the core of the mountain, though ash undoubtedly has contributed to their development also. The climate here is somewhat cooler and more humid than on the plains, topographic features are more prominent and the ridges once were forested. These circumstances have given rise to comparatively deep well-drained uniform red loams, the deepest and most fertile soils being on the higher parts and on the more prominent ridges. On the lower slopes these soils are highly erodable and are often deeply gullied and give a canyon-like appearance to the natural drainage ways. The gulley sides typically are stepped as a result of the varying resistance to erosion of an alternation of hard and soft horizons in the deep subsoil, which often occurs in these soils. The hard pan horizons are taken as representing successions of ash deposit, the soft horizons being the soil developed from these ash deposits before being buried by later ash showers.

The footslope ridges commonly finger into poorly drained bottom lands supporting a *Pennisetum catabasis* dominated grassy vegetation. Here sodium accumulation followed by solodization has been intense and has given rise to grey loamy surface soils breaking sharply to columnar structure frequently mottled heavy clay subsoils. Islands of eroded remnants of the ridge-top red soils are found out on the plain close to its eastern fringe.

The Loldaika Hills form a remnant of the old basement complex mountains which the volcanic ejectate forming the Laikipia Plains and Mount Kenya failed to overwhelm. The hills themselves are mostly eroded to the parent rock or soil material but there has been a good deal of soil accumulation in the valley floors. While it is likely that ash has contributed to soil development in these valley floor situations the soils in main are red sandy and rich in crystalline quartz grains originating from the basement rocks.

The soils which are considered suitable for irrigation comprise the deepest most uniform grumosolic clays of the Laikipia Plains and the deepest uniform friable red soils of the lower mountain slope ridges. The valley bottom soils of the Loldaika Hills though suitable for irrigation are too distant from reliable water to be used

much. Finally the river alluvium and some soils though heavy have been demonstrated as suitable for irrigation where drainage can be provided. On account of their heavy texture the irrigable plains, alluvium and swamp soils are considered best used for the production of maize and fodder crops by surface irrigation. On account of their steepness and susceptibility to erosion, the irrigable footslope soils on Mount Kenya are considered best used for the sprinkler irrigation of high-priced cash crops.

The results of the laboratory and greenhouse studies which have been carried out on the Solai and Nanyuki soils are reported in the appropriate sections later in this report.

Dr. Thorp presented a joint paper with Bellis entitled "Soils of the Kenya Highlands in Relation to Land Forms" to the 7th International Congress of Soil Science at Madison. The paper and the slides of Kenya, its landscape and its game, illustrating its presentation, were well received.

Soil Chemistry

(R. J. Kempton)

Soils data following the Mehlich procedure continue to be accumulated on samples from the surveys, the fertilizer trials and in connexion with general farm advice. The data is in process of being transposed on to maps with a view to building up a picture of the geographic distribution of the levels of plant nutrient status over Kenya and to intensifying future soil sampling in presently inadequately covered areas. Meanwhile pending the development of a firmer and more widely accepted theoretical basis for the clay characterization procedures these were omitted from soil analysis. A step towards this was made by the presentation by Mehlich of a paper entitled "Charge Characterization of Soils" and by Miller of a joint paper with Mehlich entitled "Charge Distribution as a Criterion for Classification of Some Equatorial Soils" to the 7th International Congress of Soil Science and by the discussions which these subjects stimulated at the Congress.

Laboratory studies have shown most of the Solai soils to be slightly to extremely acid and to be rather low in available phosphates and nitrogen but to be adequately supplied with the basic mineral nutrients calcium magnesium and potash and with available sulphur. The increase in available phosphorus status in the deep subsoil which was frequently observed in ash-derived soils at Songhor and East Koinyango was not found in the Solai samples. The surface soils generally were well supplied with organic matter.

In very few of the sites sampled in the Nanyuki survey was excessive salinity found to constitute a problem in irrigation but over a third of them contained significant amounts of exchangeable sodium. Most of the sites had moderately acid surface soils and were moderately alkaline at depth though excessive acidities were recorded in the swamps and in some of the more highly coloured free-drained lower mountain slope soils. Acid extractable phosphorus in general was satisfactory and in a number of sites it was high even in the surface. The tendency discerned on the ash-derived heavy textured soils at Songhor and East Koinyango for available phosphorus to be higher in the weathering rock than in the developed soil was again apparent. The surface organic status was satisfactory on most sites. Biologically determined N and even phosphorus availability of the surface soil were low while sulphur availability was variable but was seldom so low as to be of critical importance.

Bioassays

(A. Pinkerton)

A new large greenhouse which had been erected in 1959 for pot test work came into use early in 1960. In it light and temperature do not vary so much from place to place as they did in the smaller houses which had previously been used and the growth of plants has been correspondingly more even. Initially troubles were experienced due to excessively rapid drying of the soil in the small pots which are used for the greenhouse nutrient status appraisals but this was overcome by the installation of overhead shade as a result of which the temperature now seldom exceeds 96° F. and direct insolation is reduced by 52 per cent. Large capacity stills have been installed and their output is adequate for full utilization of the extensive greenhouse working space now available.

During the year 77 soils were tested for deficiencies generally by pot test and for copper and zinc status by *Aspergillus niger*. Fifty-four of these were in connexion with the delineation of the copper deficiency area in Nakuru district whose start was reported in 1959. Six were from the Sotik soil survey field work on which was reported in 1959. Twelve were from the Solai soil survey the field work on which is reported earlier in this report. Five were investigated in connexion with crop growth problems which had been encountered by departmental field staff. Pot investigation activities have been extended to application rate studies in larger pots with field crops carried through to maturity on soils in which well-defined trace element deficiencies have been established.

The Sotik soils came from or near the sites of the type profiles of the main soils recognized in the survey. They all were deficient in phosphorus and three showed responses to nitrogen. Two were very deficient in sulphur and two slightly so. No pot test indications of trace element deficiencies were recorded but one soil was rather low in available copper and two were rather low in available zinc by *Aspergillus niger*.

The Solai soils similarly came from or near the sites of the type profiles of the main soils so far recognized in the survey. Six of them were very low in nitrogen, all were very low in phosphorus and nine showed responses to sulphur though two of them only slightly. Only a soil coming from the very edge of the Menengai cauldron showed a measurable response to copper although in two other cases test plants exhibited slight symptoms of a deficiency. All the Solai soils were high in zinc but four were low in copper by *Aspergillus niger*.

Apart from those samples tested in connexion with the Solai survey half of the 54 samples from Nakuru district which were examined in connexion with the copper survey were found to be deficient to a greater or less extent. The deficient samples came from a moderately well-defined area. It appears that all the ash and pumice soils around and to the west of Mount Menengai are deficient. The Ando-like soils around Njoro also are deficient but not the dark brown loams on higher ground. The deficiency area extends westwards towards Elburgon and Rongai and northwards along the red loams on the east bank of the Molo River. No significant copper deficiency was encountered further west. Values for available copper by *Aspergillus niger* ranged from 0·3 to 11·0 p.p.m., the majority being below 2 p.p.m., which is the level most widely regarded as approximating to the threshold of copper deficiency. In all cases where there was a deficiency indication in the pot test a low value was found by *Aspergillus niger* (always below 3 p.p.m. and nearly always below 2 p.p.m.). Often however a low value by *Aspergillus niger* was not matched by a response in the pot test. In addition to the pot test and *Aspergillus niger* determination a number of the soils were analysed for total copper using a hydrogen fluoride extraction but no relation was found between total copper and copper availability.

In the light of information derived in the copper survey, copper sulphate application rate studies were undertaken on three representative soils: these were a rich loam from near Rongai, and Ando-like soil from near Njoro and a pumice soil from the eastern edge of Menengai. Wheat was used as the test crop on account of its local importance and of the considerable body of local farming information that this crop needs copper fertilizing when grown near Nakuru. Each test comprised eight pots with approximately 12 lb. soil per pot. A basal dressing of the major elements was added using purified solutions equating a rate of 2 cwt. per acre double superphosphate and 2 cwt. per acre sulphate of ammonia with other essential nutrients added in proportion. Copper sulphate solutions equivalent to 5, 10, 20, 40, 80 and 160 lb. per acre were then added to single pots while two pots in each test received no copper. On the recommendation of the Senior Plant Breeder the variety of wheat used was H462, this being a short-term variety which is adapted to low altitudes. Six plants were grown to maturity in each pot and these were harvested 12 weeks after sowing. The seed harvested from the first test was resown in its old pot after a reapplication of its nitrogen phosphorus and copper dressings. Ultimately a third crop similarly was taken after application of a double dressing of nitrogen and phosphorus and a second reapplication of the copper treatment. Samples of soil from each pit were taken after each crop was harvested and were analysed for total copper.

Although the three tests were intended merely as guides to future field and large pot greenhouse tests and although all analyses are not yet completed several points already emerge.

(1) Responses were obtained in all three soils though except in the case of the pumice soil the copper responses have declined as successive crops have been taken. This decline may be due to contamination introduced during the nine months the tests have run though in the case of the pumice soil the deficiency seems so extreme that the no copper seed actually failed to germinate and establish a stand in the third planting.

(2) Lack of copper affects the wheat plant in several ways: the plant itself is smaller and the ears are shorter. There are fewer tillers and there is a smaller yield of grain and straw. The plant is more susceptible to drought and maturation is delayed. On the other hand neither individual grain weights nor grain to straw ratios are affected.

(3) The copper content of the grain rises as the fertilizer copper application increases to a maximum of 9 p.p.m., an application equating between 20 and 40 lb. per acre copper sulphate being sufficient to raise the seed copper level to the 6 to 8 p.p.m. level which is typical of the levels attained by the higher copper applications. Maximum yields were given by rates of about 40 lb. copper sulphate per acre in the first harvest but by the third crop repeated applications of 10 lb. per acre were yielding as well as any other treatments.

(4) The available copper in the no copper soils in all three groups rose from test to test. A possible explanation of this is that in spite of the careful purification, the successive additions of water and chemicals have been sufficiently large for the small amounts of copper they still contain after purification to have accumulated in significant amounts in the soil in the pots. Alternatively the wetting and drying of the soil may have increased the availability of some of its total copper.

(5) The phosphorus in excess of that taken up by the crop is largely fixed in an insoluble form. In the Rongai loam, the 2 cwt. per acre double supers dressing just maintained the level of acid extractable phosphorus while the 4 cwt. per acre dressing succeeded in raising this figure from 18 p.p.m. to 22 p.p.m. Neither of the rates of application could keep pace with use and fixation on the Ando-like soils and the level of available phosphorus during cropping on this went down from 17 p.p.m. to 10 p.p.m. Similarly available phosphorus in the pumice soil went down from 17 to 11 and finally to 6 p.p.m.

Pot tests on the general investigational samples focused attention on the need for ensuring adequacy of supply of major nutrients and of cultural standards in dealing with field problems. Gross phosphorus deficiencies were apparent in all cases. In one particular case, a recommendation of better ploughing and mineral nitrogen application in irrigation water which resulted from field examination and greenhouse investigations rectified a hollow stem condition in cauliflowers which the grower had been convinced was due to a boron deficiency. Adequate major nutrients once applied, and cultural procedures adopted, the need for the trace elements to whose lack this and so many other instances of poor growth are attributed may well disappear.

Its salinity presented several problems with the pot testing of a soil from Galole of low infiltration capacity, high susceptibility to caking and high soluble salt content. However subsidiary experimentation established that extra shading alone was necessary for satisfactory and uniform growth to be obtained. This provided, the test then pointed to a trace element deficiency being present which the parallel *Aspergillus niger* determination pinpointed as being likely to be due to a zinc deficiency. A pot test specifically to confirm this zinc deficiency indication failed to substantiate it satisfactorily.

A subsidiary study was the comparison of a variety of nitrogen sources for fertilizer purposes. These were:—

(1) A sample of meat offal from the K.M.C. (whose high fat content was thought possibly to have deleterious effects) supplemented with non-nitrogenous nutrients.

(2) A commercial nutrient solution—Solufeed.

(3) The nutrient solution used in routine pot tests at Scott Laboratories, and

(4) A nutrient solution with the same nutrient content as that in the routine pot test solution but with nitrogen supplied solely as ammonium nitrogen (in contrast with the nitrate form used in the routine pot test solution).

All nutrients were applied at a rate equivalent to 4 cwt. per acre sulphate of ammonia, tomatoes were used as the test crop, the pots used were of 1 gallon capacity and the tomatoes were carried through to harvest. In the final result there was little to choose between the treatments except that application of nitrogen solely as ammonium nitrogen caused severe leaf scorch. Meat meal proved a good supplier of nitrogen and, if worked into the soil repeatedly, improved the structure and moisture retention properties of the Kikuyu red loam used in the test, considerably. It was not so good as a seed bed top dressing however as its use led to a bad growth of fungus on the surface and to severe damping-off of the young seedlings.

Fertilizer Trials

(E. Boswinkle)

The fertilizer trials programme in African Areas was continued in 1960, a total of 102 trials being successfully harvested in the long rains. These were distributed:—

Province	Exploratory Trials		Rates Trials	
	New	Residual or reapplication	New	Residual or reapplication
Central	0	20	0	12
Coast	0	12	0	0
Nyanza	0	26	1	4
Rift Valley ..	2	5	1	2
Southern.. ..	7	8	2	0
	9	71	4	18

Responsibility for the execution of these trials passed largely to Provincial staff and the programme was scaled down to their resources. The main emphasis was placed on the rates trials. These are envisaged as long-term trials covering at least one full rotation cycle and preferably more. They aimed at providing information on the cumulative as well as the short-term effects of applying fertilizers and manure. The majority of the new exploratory trials were started in connexion with the investigation of the fertilizer requirements of pallid sandy soils derived from siliceous rocks. The needs of these soils had been much less thoroughly investigated in previous years than the needs of the deep red friable soils derived from volcanic rocks and special efforts have proved necessary in the securing of suitable sites.

The results of the 1959 trials were accumulated and analysed. The overall means for the more frequently tested crops in the successful trials are as shown in the following table, the number of trials contributing to each mean being shown in brackets below each mean and the number of trials in which the benefit from the fertilizer or manure application was significant being indicated by the asterisked figure below the bracket figure.

Crop Particulars	Double Superphosphate			Sulphate of Ammonia			Manure				Muriate of Potash	
	0	¾–1½ cwt.	2–3 cwt.	0	1–1½ cwt.	2–3 cwt.	0	4–7½ tons	10–12 tons	15–22 tons	0	½–2 cwt.
English potatoes, bags per acre	39·8 (22)	53·8 (17) 6*	51·1 (20) 10*	44·3 (20)	54·5 (12) 2*	49·1 (19) 5*	42·5 (18)	48·4 (4) 1*	62·1 (10) 5*	50·4 (15) 8*	34·7 (7)	35·5 (7) 1*
Maize, 1 and 2 seasons residuals on red soils from volcanic rocks, lb. per acre.	2,155 (14)	2,574 (12) 5*	2,709 (10) 3*	2,381 (14)	2,462 (15) 0	2,568 (15) 0	1,988 (13)	2,306 (6) 3*	2,763 (6) 2*	2,405 (9) 4*	1,979 (5)	2,190 (7) 0
Maize reddish soil from siliceous rocks, lb. per acre.	2,782 (4)	3,061 (6) 1*		2,528 (4)	3,230 (6) 4*		2,603 (4)	3,180 (6) 5*			2,578 (2)	2,893 (2) 0
Maize pallid soils from siliceous rocks, lb. per acre.	1,938 (5)	2,597 (6) 4*		1,949 (6)	2,538 (7) 2*	3,153 (3) 1*	1,623 (4)	2,642 (5) 3*		— —	1,531 (3)	1,561 (3) 0
Beans 1–3 seasons residuals on red soils from volcanic rocks, lb. per acre.	301 (14)	337 (11) 2*	398 (10) 2*	314 (15)	360 (11) 1*	351 (10) 0	269 (14)	304 (6) 0	421 (5) 1*	411 (10) 4*	295 (8)	291 (8) 0
Beans 1–3 seasons residuals on sandy soils from siliceous rocks, lb. per acre.	244 (4)	267 (4) 1*	—	280 (4)	331 (5)	—	222 (4)	290 (4) 1*	—	—	—	—
Red sorghum 1–4 seasons residuals, lb. per acre.	556 (6)	762 (6) 0	—	654 (6)	685 (6) 0	—	582 (6)	746 (6) 2*	—	—	717 (5)	685 (5) 0
Cotton, lb. per acre	727 (3)	756 (3) 0	—	736 (3)	748 (3) 0	—	736 (3)	747 (3) 0	—	—	741 (3)	743 (3) 0
Sweet potatoes, cwt. per acre	101 (4)	100 (4) 0		99 (4)	102 (6) 0		97 (4)	103 (4) 0			100 (3)	99 (3) 0

NOTE.—The residuals in main relate to residuals from phosphate and manure application, usually with reapplication of the sulphate of ammonia and muriate of potash to the test crop though where beans were used the nitrogen reapplication normally was omitted.

The responsiveness of English potatoes on deep friable red soils derived from volcanic rocks and of maize, sorghum and beans on a variety of soils to double superphosphate application or its residuals and to manuring and of maize on pallid sandy soils derived from ancient siliceous rocks and of English potatoes to sulphate of ammonia application once more was apparent. Cotton and sweet potatoes in the few trials concerned showed little or no promise of responding to the fertilizers tried or to manure. None of the crops responded appreciably to the muriate of potash dressings.

The accumulated results of the trials from 1956 to 1958 were examined in detail in 1960. Significant or highly significant mathematical relations were established for deep friable red soils derived from volcanic rocks between the dilute acid extractable phosphate status of the soil or the availability of its native phosphate content as measured by Cunninghamella test and the following field measurements:—

(1) The percentage response relative to the control yield of English potatoes to an application of 2 cwt. per acre double superphosphate or 15 tons per acre FYM.

(2) The percentage response of beans to the residual of an application of 2 cwt. per acre double superphosphate or 15 tons per acre FYM applied to potatoes the previous season.

(3) The percentage response of maize to the residuals of 2 cwt. per acre double superphosphate or 15 tons per acre FYM applied to English potatoes two seasons previously with an intervening unfertilized crop of beans.

(4) The percentage response of maize to a direct application of 1 cwt. per acre double superphosphate or 7½ tons per acre FYM.

(5) The application of double superphosphate which by calculation from the field trials yield data would give the maximum yield of English potatoes.

(6) The maximum response of English potatoes which by calculation may be expected from the application of double superphosphate.

The percentage response of English potatoes to the 2 cwt. per acre double superphosphate application was significantly related to the yield of the control plot. Dilute acid extractable soil phosphorus measurements sucessfully detected the enhancement of available soil phosphorus on a deep friable red soil derived from volcanic rocks though the magnitude of the residue represents only 12 or 13 per cent of the phosphorus added in the fertilizer. Maize responded as well or better to the residuals from the phosphate and manure applications to potatoes two seasons previously as it did to the direct fertilizer or manure application. On the other hand potatoes made very little use of the residuals from application to maize. There was a distinct lack of interaction of importance between the fertilizer and manure effects.

No significant relationships were discerned between the sulphate of ammonia or the muriate of potash and laboratory measurements of nitrogen or potash status or availability. An account of these trials and of the response relationships was prepared and submitted for publication in the *Empire Journal of Experimental Agriculture.*

A parallel review was undertaken of trials which had been carried out at a number of stations with the object of studying the cumulative and residual effect of phosphate fertilizer application and of determining the optimum distribution of a given dressing of double superphosphate over the arable phases of a rotation. The results of these trials supported numerous earlier observations that the phosphate in double superphosphate is more effective than that in soda phosphate, that the phosphate in both of these is much more effective than that in Uganda rock phosphate and that the effect of all three forms persists over a number of years after application. The residual effectiveness of the phosphate in double superphosphate is distinctly greater than that in the other fertilizers tried in the early years after application but declines to the level of the others with time. On red soils derived from ancient siliceous rocks, significant residual effects from applications of 1–2 cwt. per acre double superphosphate can persist over 5–9 seasons. Double superphosphate was found best applied to English potatoes and unless the English potatoes receive a good part of the phosphate

application the production of the rotation on a phosphate needing soil is severely impaired by the fall in potatoes yields which results. English potatoes proved the most satisfactory crop with which to start the rotation out of grass and this crop could with advantage receive most or all of the phosphate applied to the rotation. Maize did badly when used as the breaking crop and yielded best in the third, the last year in the arable break. The timing of the superphosphate application in relation to the crop sequence had important effects on the profitability of double superphosphate used in the rotation. These reviews have been submitted for publication partly in the *Empire Journal of Experimental Agriculture* and partly in the *East African Agricultural Journal* (The Application of a Phosphate Fertilizer on Different Crop Rotations in Kenya: E. Boswinkle: *E. Afr. agric. for. J.* Volume 26 (1960), 65–67).

Lime Trials

(Dr. L. A. Whelan)

Three of the long-term lime trials begun in 1953 were continued during the year. All sites are now down to grass. Apart from a lime reapplication at Marindas nitrogenous fertilizer dressings alone were given.

At Eldoret the grass was cut for hay in July, the table of mean yields as cwt. per acre being:—

	L_0	L_1	L_2	M		
(1)	5·71	7·80	8·65	8·04	7·55	
K	5·88	7·94	7·77	7·06	7·16	s.e. of difference 0·58
NK.. ..	8·44	10·91	15·35	12·13	11·70	5% L.S.D. 1·18
	6·67	8·88	10·58	9·08	8·80	

s.e. of difference 0·67
5% L.S.D. 1·37

	P_0	P_1	P_2	
(1)	8·34	6·36	8·03	7·55
K	9·22	5·14	7·12	7·16
NK	10·36	13·75	10·99	11·70
	9·28	8·41	8·71	8·80

s.e. of difference 0·58

There were highly significant differences between the average yields associated with the lime treatments ($P<0{\cdot}1\%$). The L_1 application gave a significant increase in hay yield of $2{\cdot}21 \pm 0{\cdot}67$ cwt. per acre while the additional application at the L_2 level gave a further increase of $1{\cdot}70 \pm 0{\cdot}67$ cwt. ($P<5\%$). The yield given by the calcitic limestone (M_1), 9·08 cwt., was significantly greater than where no lime was applied (6·67 cwt.) and significantly less than the average yield where lime was applied at the L_2 level (10·58 cwt.). It differed little from the yield secured when the equivalent dolomitic limestone dressing L_1 was given.

There were highly significant differences between yields associated with the potash and nitrogen treatments. This arose from the large response to nitrogen applied in the presence of potash, this resulting in an increase of yield of 4·54 ± 0·58 cwt. There was no evidence of any response from potash applied on its own. Yields associated with superphosphate treatments are not significantly different. There was significant evidence ($P<1\%$) of differential effects of the NK treatments at different phosphate levels but as components of the interactions concerned are confounded, full information is not available.

At Marindas, the deterioration in the pasture had become so advanced by the end of 1959 that the plots were ploughed up and replanted in April/May with a grass/clover mixture. Prior to replanting, half of those plots which received an initial lime treatment were given a second application of calcitic limestone in association with levels of calcined magnesium carbonate application aiming to secure an adequate scatter of calcium/magnesium soil ratios in addition to a good range of soil acidities.

At South Kinangop a grass cut had been taken in December, 1959, the table of mean yields as tons per acre being:—

	L_0	L_1	L_2	M		
(1)	3·3	4·3	5·5	4·2	4·3	s.e. of difference 0·7
NK.. ..	4·9	5·6	7·7	5·7	6·0	5% L.S.D. 1·4
	4·1	4·9	6·6	5·0	5·2	

s.e. of difference 3·8

	P_0	P_1	P_2	P_3		
(1)	4·6	3·9	4·8	3·9	4·3	
NK.. ..	6·1	6·5	6·4	4·9	6·0	5% L.S.D. 1·4
	5·4	5·2	5·6	4·5	5·2	

s.e. of difference 3·2

The nitrogen/potash mixture produced a significant increase in yield of 1·7± 0·7 tons per acre. There were no other significant effects.

For observation purposes a modification was made in the ammonium sulphate application given in November, 1959. The NK plots of replicate No. 1 were given 100 lb. per acre and those of replicate No. 2 were given 200 lb. per acre. The mean grass yields obtained were:—

Ammonium sulphate application per acre ..	Nil	100 lb.	200 lb.
Yield, tons per acre	4·3	5·0	7·0

With the additional 100 lb. of sulphate of ammonia went a marked increase in yield over that from the smaller application. There was no evidence to suggest that the differences arose from fertility variation over the trial and the difference in growth which was apparent, was apparent right along the border between the replicates.

A comparison was made between the average yields from all the plots which had received one lime application (1954) with those which had received two (1954 and 1959):—

Mean yield of plots given one application: 4·57 tons per acre.

Mean yield of plots given two applications: 6·43 tons per acre.

s.e. of difference 0·77: L.S.D. 5% 1·59.

The reapplication of lime had increased the yield of grass by nearly two tons per acre.

In the laboratory, samples of rye grass taken from the Marindas trial in October, 1958, were analysed for mineral content. In the summary below the results are expressed as percentages of treatments other than those specified:—

1954 Lime Application	Nil (L_0)	8,300 lb. per acre Dolomitic Limestone (L_1)	15,000 lb. per acre Dolomitic Limestone (L_2)	7,400 lb. per acre Calcitic Limestone (M_1)
Ca	0·33	0·40	0·44	0·44
Mg	0·23	0·26	0·26	0·24
P	0·17	0·18	0·19	0·18
K	2·62	2·76	2·94	2·91
Mn	0·036	0·020	0·013	0·023

The lime applications have increased the calcium content of the grass appreciably and the magnesium phosphate and potash contents to less extent. They have led to a considerable decrease in manganese content. The magnesium content of the herbage was not much affected by the type of limestone used.

1958 Superphosphate Application	Nil (P_0)	100 lb. per acre (P_1)	200 lb. per acre (P_2)	400 lb. per acre (P_3)
Ca	0·37	0·41	0·41	0·42
P	0·12	0·16	0·21	0·24

A slight increase in calcium and a large increase in phosphorus are apparent as a result of the superphosphate application.

1957 NK Application	Nil	200 lb. per acre each of Sulphate of Ammonia and Muriate of Potash
K	2·58	3·03
P	0·19	0·17

The nitrogen/potash mixture application brought about an appreciable increase in potash and a small decrease in phosphorus content.

The effect of the 1959 lime reapplication at South Kinangop was studied on surface soil (0–8 inch) samples taken in December, 1959. The main analytical data obtained is summarized below. The calcium and magnesium figures relate to the dilute acid extractable content as determined by the rapid Scott Laboratories procedure.

		Not Reapplied			Reapplied		
	L_0	L_1	L_2	M	L_1	L_2	M
pH	5·1	5·4	5·8	5·4	6·0	6·4	5·9
Ca me% ..	3·0	3·7	5·1	4·0	6·5	8·2	6·6
Mg me% ..	0·6	0·8	0·9	0·7	0·8	1·2	0·7

The reapplication has had a considerable effect on pH and on dilute acid extractable base content and has generally widened the calcium/magnesium ratios. In particular, where calcitic limestone (M_1) was reapplied, the calcium/magnesium ratio is now over 9, compared with the control ratio of 5. The phosphorus status is as follows:—

Treatment	P_0	P_1	P_2	P_3
P Acid Extractable	18	24	30	54 p.p.m.
P Cunninghamella	39	45	52	61% of complete nutrient growth

While the enhanced availability of the soil phosphorus in the phosphated plots is considerable the South Kinangop grass yield response table given earlier in this report shows that the early needs of the grass must have been met by the basal dressing of 100 lb. double superphosphate per acre which was given over the whole trial at seeding.

Soil Physics

(Dr. D. D. Evans)

The facilities for soils investigations which are available at Scott Laboratories broadened still further with the arrival at the end of July of Dr. D. D. Evans to take up the appointment of Soil Physicist under the International Co-operation Administration. Basic soil moisture tension measurement and soil moisture content measurement apparatus had been accumulated in anticipation of Dr. Evans arrival and his first task was to see to its installation. Subsequently the balances, oven, sample containers, core-sampling equipment for moisture retention studies, bulk density determinations and permeability measurements, together with equipment for the mechanical analysis of soils by the pipette method were got together or fabricated. The main laboratory was set up at Scott Laboratories and a small laboratory was equipped on the Kano Experiment Station for making soil moisture content measurements. The establishment of this last laboratory involved the provision of plant with which to generate electric power for heating the oven.

Initial activities have concerned the provision of facilities for the control of irrigation experiments on the Kano Plains near Kisumu, initially on sugar cane and on cotton, the development of methods for the modification of infiltration rates on soils at Perkerra and Mwea which had proved difficult to irrigate and the measurement of soil moisture status in connexion with crop sequence studies in semi-arid conditions currently being undertaken at Katumani near Machakos. The Katumani trial was inspired by an observation in 1959 that Sudan grass on land which in an experiment under our fertilizer trials programme had been fallow the previous season grew better than Sudan grass on land which in the same experiment had been under maize the previous season. These observations drew the attention of the Katumani staff to the importance of crop sequence in land use at Katumani and underlined the need for designing crop sequences with a view to soil moisture storage under the conditions of uncertain rainfall which prevail there.

The initial trial in the Katumani crop sequence trial programme set out to compare the effect which long-term maize, short-term maize, silage maize, beans and a weed-free fallow would have on a uniform test crop of maize planted on the same land the following season. In the event, the individual plots were split to provide for a comparison of long-term maize and short-term maize as the test crop. The treatments were applied in the long rains and the control was sampled for moisture determination in November to ascertain the effect of the different cropping systems on soil moisture content. Samples for wilting point (15 atmosphere tension) and field capacity ($\frac{1}{3}$ atmosphere tension) determinations were also taken, these with the intention of estimating the amount of water the soil would hold on the basis of accepted concepts. The measurements showed that all the crops removed virtually all the available water in the profile to the depth of about 5 ft. to which sampling was undertaken. The beans and the silage maize appeared to leave a little more water in the soil at depth than did the two crops of maize while even though the fallow land contained more water than the cropped land, this amounted to only $2\frac{1}{2}$ inches of the 9 inches of rain which had fallen the previous season. Even so this $2\frac{1}{2}$ inches of stored moisture made outstanding differences in the test crop, to the extent that the best treatment—the combination of bare fallow with a short-term maize yielded over 2,000 lb. an acre while the worst—a long-term maize following a long-term maize—yielded under 60 lb. per acre.

Wheat Protein Chemistry

(H. C. Hodgson)

Attempts to achieve the electrophoretic separation of gluten proteins continued. Through the good offices of the National College of Rubber Technology and Dunlopillo Ltd., samples of foam plastic and of additive-free natural foam rubber were obtained and electrophoresis bridges were constructed of them, the natural rubber foam first being digested with trypsin to remove any residues which might have been present of the casein which would have been used in its manufacture. Even with these bridges, recovery of the added protein after electrophoresis remained poor while the reproducibility of the zonal patterns which were obtained was inadequate. It was found that for the protein to be trapped on the bridge it was necessary for it to have been subjected to electrophoresis, this indicating that during electrophoresis the proteins which became fixed became fixed by migration into dead spaces in the foam cells where they were inaccessible to the extraction process.

The use of the sponge rubber bridges having been unsuccessful, a new approach to the electrophoresis of gluten proteins, following a method which Shaw (*Nature* 180 (1957) 643–645) had found successful in the study of wool protein, was tried. The Shaw method concerns conversion of the natural proteins into soluble derivatives by treatment with cupric and sulphite ions. The treatment leads to the fusion of cysteine disulphide bonds in protein structure and the transformation of these and of the cystine groups to thiosulphate derivatives. Price and McDermot (*Nature* 184 (1959) 546–547) applied the solution technique to wheat proteins and succeeded in rendering about 98 per cent of the protein in wheat flour soluble by the Shaw treatment. At Scott Laboratories the Shaw treatment was found readily to solubilize the protein in the freeze-dried glutens from the Kenya wheats which had been prepared at the start of these protein chemistry investigations and the products, after dialytic removal of excess reagent, were found freely to disperse in borate buffer of pH 7·5–8·5, giving clear solutions. Electrophoresis of the sulpho-cystenyl gluten derivatives was found to give indistinct zonal separation on filter paper strips, but using carboxy-methyl cellulose strips (a cation exchange form of paper) at least five distinct fractions have been discerned. The quantitative estimation of these zones by the normal scanning procedure proved impracticable however as the only dye which would stain the modified proteins is nigrosine and the composition and staining properties of this dye are too irregular for quantitative assays. Procedures for treating the modified glutens after electrophoresis so that they will stain quantitatively are being sought.

Meanwhile the possibility of fractionating sulpho-cystenyl glutens chromatographically on anion exchange columns is being investigated. Initial work having shown that proteins in a low ionic strength borate buffer are taken up and held by amberlite IRA 400 resin, suitable apparatus for the chromatographic separations and subsequent recoveries involved is being assembled.

The starch gel electrophoresis method used by Elton and Ewart (*Nature* 187 (1960) 600–601) on wheat flours with the aluminium lactate buffer system found by Jones *et al* (*Anal. Biochem. et Biophys.* 84 (1959) 363) to give good results with gluten proteins by moving boundary electrophoresis was also investigated. A replica of the starch gel apparatus devised by Smithies was constructed and with it a clear separation of some of the components of the freeze-dried glutens has been obtained. At the same time the separation was marred by a broad band of colloidal particles which masks the separation of the slower-moving constituents. For this to be removed, the sample will need to be clarified in an ultra centrifuge prior to electrophoresis. Further progress with the method awaits the ordering of suitable ultra centrifuge equipment.

Wheat Maturation Trials

(H. C. Hodgson)

The 1958 wheat maturation trial at Ol Joro Orok was repeated using two sowings of Regent, one of which failed owing to excessive game damage. The remaining sowing was harvested at weekly intervals on six occasions starting three weeks before the estimated full ripeness of the crop. The harvests were examined by the Unga Laboratory for bushel weight, dough strength, distensibility, protein content, maltose and loaf size. Bushel weights rose from 60 lb. at the first harvest to 63 at the second and then declined to 58–59 by the last harvests. Dough strength rose from an initial value of 62 to a peak of 80 at the third harvest and then declined slowly to a terminal value of 70. Distensibility as measured by the L/P ratio widened from 1·27 at the first harvest to 1·84 in the fourth and fifth and then narrowed to 1·73 in the last. Protein content already high at the initial harvest rose only slightly thereafter and eventually decreased by about 1 per cent. Maltose content tended to drop with advancing maturity from 304 in the first harvest to 240 in the last. Loaf size throughout was between $42\frac{1}{2}$–$43\frac{3}{4}$ inches. As the harvest season was warm and dry ripening was rapid and a high strength level and good baking qualities were achieved and maintained.

Crop Product Development

(H. C. Hodgson)

Essential Oils

This year has seen an increased interest in the growing of Reunion geranium as a crop and there has been a steady demand by new growers for planting material from the laboratory plots. The culture of geranium has been extended to the African areas with the establishment of a pilot scheme at Embu.

The quality of geranium oil is to a considerable extent dependent on the stage of development of the plants as determined by local climatic conditions, oil from young growth having an undeniably sharp odour and lacking the heavy "note" obtained from fully matured material. With the object of seeking information on the variation of oil composition with plant development, a harvesting trial was conducted on 25 selected plants at the Upper Kiambu Coffee Research Station. Commencing in July, at the end of the long rains, a series of five successive monthly harvests were cut and the material glass-distilled, the oils being despatched to the Tropical Products Institute for gas liquid chromatographic analysis. A pronounced fall in oil yield was observed at the fifth harvest when the plants were flowering, the stage at which harvesting would normally be undertaken. With this fall in yield went a distinct mellowing in the quality of the oil.

Citrus Juice

Further monthly harvests of lemon were taken and the juice pasteurized, preserved with sulphur dioxide and despatched to Schweppes Ltd., London, for assessment. As a result of their examination Schweppes Ltd. have expressed willingness to purchase lemon juice from commercial producers in Kenya provided it attains the quality of the samples we submitted.

Analytical Data

(R. J. Kempton)

The following analytical data obtained during 1960 is of general interest:—

Foodstuffs and Plant Tissues

Commodity	Moisture %	Oil %	Crude Protein %	Fibre %	Ash %	
Brewers grains	12·6	5·1	14·1	14·2	4·3	
Castor seed	3·7–4·3	45·1–51·4	—	—	—	
Chicken meal	11·8	3·9	16·8	5·9	6·9	
Dried skim milk	12·8	—	65·5	—	4·7	
Gram hulls	11·4	1·8	9·4	39·6	8·2	
Grass, H1 Rye	4·4	2·9	14·7	27·6	14·4	
Grass, Rompha	6·6	4·6	26·0	19·8	15·8	
Grass, Rongai Rhodes, milled	10·0	1·4	4·7	36·8	9·4	
Grass, vleiland	5·8	1·1	3·0	33·7	13·1	
Lucerne	6·6–13·7	2·3–4·5	18·6–28·8	10·6–23·9	9·6–13·1	
Lucerne, dried early flowering	6·9	2·1	22·2	21·7	10·1	
Lucerne meal	4·9–10·9	2·6–6·4	16·5–27·8	21·4–28·3	9·2–10·6	
Lupin seed	—	—	—	—	—	Alkaloid 0·01–0·24%.
Maize, cob cores, milled	11·6	0·5	1·9	35·3	1·4	
Maize, granulated	12·9–13·6	4·1–5·0	—	0·7–1·1	—	
meal	13·2–13·8	2·8–6·2	—	0·8–2·2	—	
stack sievings	11·9–17·5	0·8–8·9	17·6–27·5	4·8–7·1	14·3–29·1	
Oats and Rape	79·4	0·5	3·2	4·6	2·8	
Pig meal finishing	11·7	6·1	13·6	5·3	5·1	
Pig meal sow and weaner	11·3	7·3	16·7	4·4	7·1	
Rape	2·4	2·7	12·5	17·5	12·8	
Rice bran	8·0–10·5	5·4	4·8–5·7	23·8–30·1	19·1–21·2	
Rice dust	8·8	—	5·9	30·7	—	
Russian Comfrey	10·2–13·5	1·7–3·1	15·6–26·6	7·6–8·1	20·6–30·1	
Silage maize	87·8	0·4	1·5	4·4	2·6	
Silage maize and oats	86·9	0·5	1·6	3·9	2·5	
Silage oats, red soil	82·1	0·8	2·2	5·3	1·7	
Silage oats, vleiland	72·9	0·8	2·6	11·2	2·4	
Sunflower black large	7·4–7·9	26·8–27·7	—	—	—	
Sunflower black small	7·2–8·0	29·0–29·1	—	—	—	
Sunflower white grade I	7·4	29·2	—	—	—	
Sunflower white grade II	7·0	31·0	—	—	—	
Sunflower White Nile, large	8·4	28·8	—	—	—	
Sunflower White Nile, small	7·7	29·6	—	—	—	
Sugar beet	62·1–86·4					Sucrose 7·5–24·6%

MANURES, FERTILIZERS AND MINERAL SUPPLEMENTS

COMMODITY	Moisture %	N %	P_2O_5 %	K_2O %	Ash %	
Agricultural lime	1·1	—	—	0·3	62·0	Acid insoluble 9·7% Hydrous Oxide 2·1% CaO 48·1% MgO 0·5% Na_2O 0·6%
Bat guano	—	0·7–1·7	6·6–11·7	—	—	
Bone meal	—	1·7	24·6	—	62·8	CaO 37·3%
Chicken manure new	6·6	1·2	9·2	3·0	38·5	CaO 1·0% MgO 1·32%
old	4·5	1·3	11·3	0·9	64·5	Gravel 43·5% CaO 17·1% MgO 2·9%
Coffee *buni* ash	9·4	—	7·1	37·4	72·4	Acid insoluble 16·7%
Deep litter poultry manure	11·0	2·2	2·7	3·3	39·8	
FYM Matuga	72·1	0·7	0·4	1·1	9·6	
Geranium waste decomposed	12·6	2·5	1·3	3·1	33·0	Na_2O 1·4%
fresh	11·4	1·3	0·5	2·6	13·8	Na_2O 0·8%
Hydroponics fertilizer ..	15·4	9·0	20·9	26·0	—	CaO 5·0% MgO 1·8%
Japanese magnesium phosphate.	—	Total	22·6–22·8			
		citric soluble	20·2–22·0			
Limestone stockfeed ..	—	—	—	0·1	39·7	CaO 50·3–54·5% MgO 0·8–·36% Na_2O 0·9%
Minjingu rock phosphate unground.	—	Total	33·6	—	—	
		citric	24·9–	—	—	
		soluble	25·2			
Muriate of Potash	5·0	—	—	60·0	—	
Seychelles guano	5·2–12·8	—	26·8–28·4	—	—	
Sisal flume waste	88·2–90·1	0·07–0·08	0·02–0·04	0·12–0·14	1·0–1·7	CaO 0·48% MgO 0·10%
Soda phosphate	—	Total	21·7	—	—	
		citric soluble	14·5	—	—	
Sulphate of potash ..	1·1	—	—	51·8	—	SO_4 48·6% Cl 3·1% Water insoluble 2·2%
Triple superphosphate ..	—	Total	45·2–45·3	—	—	
		citric soluble	43·3–43·6			

Publications

Soil Survey of the Songhor Area: Thorp *et al*, Government Printer, Nairobi, 1960, pp. 193, maps 3.

The Application of a Phosphate Fertilizer on Different Crop Rotations in Kenya: E. Boswinkle, *East African Agriculture and Forestry Journal*, Vol. 26, 65–67.

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laboratory equipment and the employment of Dr. D. D. Evans, a Soil Physicist, it enabled the Senior Soil Chemist, Mr. E. Bellis, to travel extensively in America during the year and to participate in the 7th International Congress of Soil Science at Madison, Wisconsin. The National Science Foundation of the United States Government through the International Soil Science Society also contributed generously to the cost of his participation in the conference. Dr. and Mrs. James Thorp head the list of those American soils workers who gave abundantly of their time and hospitality towards the success of this tour.

Finally the Chemistry Section must express its gratitude for the continued co-operation and forbearance of the farming and commercial public in the contacts which it has with them.

E. BELLIS,
Senior Soil Chemist.

ANNUAL REPORT OF THE SENIOR PLANT BREEDER, 1960

I—Review of the Year

Rainfall was poorly distributed in 1960, and a drought developed soon after planting in the main wheat areas of the Highlands. Losses of crop were fortunately limited in extent and in general wheat yields were expected to benefit from the dry conditions and rival those of 1959. However, stem rust broke out extensively in the latter part of the season causing heavy reductions in the wheat crops in the higher districts. The overall yield is therefore lower than had at one time seemed likely. The rust situation which caused this is discussed in detail later in this report and that of the Plant Pathologist which accompanies it.

TABLE 1—NJORO RAINFALL, 1960 (INCHES)

Month	1960	31-Year Average	Month	1960	31-Year Average
January	0·39	1·02	July	1·23	4·33
February ..	0·69	1·35	August ..	8·94	5·02
March	4·57	2·80	September ..	3·71	2·78
April	2·64	5·25	October ..	2·34	1·99
May	4·53	4·62	November ..	1·74	2·57
June	0·67	3·21	December ..	1·00	1·79
			TOTALS ..	32·45	36·73

A grant of special funds from the Colonial Development and Welfare Scheme was recorded last year, and has now enabled work on rust research and maize breeding to be considerably enhanced. In the case of rust research it has provided extra facilities and staff at a time when the rust position in the wheat industry has taken an unfortunate turn. The large new ventilated glass-house constructed this year has very markedly increased the capacity for rust testing and is proving very satisfactory.

This has been the first full season of the expanded maize programme based on Kitale, and the breeding work was begun at Kakamega for the first time. At both sites the grant of C.D. & W. capital monies enabled extension and improvement of buildings to be undertaken to accommodate the new staff adequately. Multiplication of the Kitale Synthetic II was successfully completed this year and it goes on the open market for seed sales for 1961. Following its steady and yet adaptable performance in trials it should be a valuable contribution to the maize industry.

Due to leave arrangements, activity at Katumani was somewhat reduced in scope in 1960, but the value of the quick variety Taboran for short season areas and of the Early Synthetic has become increasingly apparent. Both these maizes were selected and multiplied there for Southern Province.

The start of a field approval scheme for seed wheat considerably increased the activity on the seeds side of the section this year. This now supplements the certification carried out under the Seeds Ordinance of 1955 and is applicable to any established variety. Certification itself remains largely confined to new varieties for release, of which there were ten under multiplication in 1960.

Again it is with much appreciation to various sponsors that overseas visits by several members of the Plant Breeding Service can be recorded. A Kenya Development Scholarship awarded to the Assistant Plant Breeder enabled him so study for a year at Cambridge, mainly specializing in cytogenetics. The International Co-operation Administration arranged for the author to make an extensive tour of wheat breeding in the U.S.A., to which were added supplementary visits in Canada and Mexico. The Rockefeller Foundation was mentioned in last year's report in relation to the visit of the Senior Plant Breeder to Central and South America; the Foundation have, in fact, continued to show considerable interest in the section, giving further awards for study travel and very recently for additional research activity. A substantial award for the latter purpose was announced at the end of the year and will become effective in 1961.

II—Survey of Field Crops

The wheat acreage continues to be unstable and the official figure for 1960 shows a fall to some 220,000 acres. This compares with the peak figure of 345,000 acres in 1955, as is shown in Table 2 which quotes acreage and yield data for wheat and other cereals.

The maize acreage (European production) has steadied after the sharp decline in both the previous years. Barley was over-produced in 1959, and the subsequent fall in acreage reflects the poor returns from barley sales last year rather than any crop hazard.

TABLE 2—CEREAL ACREAGES, 1955–1960

Year	Wheat		Maize		Barley		Oats	
	Acres '000	Bags/ acre	Acres '000	Bags/ acre	Acres '000	Bags/ acre	Acres '000	Bags/ acre
1955..	345	3·93	158	7·89	24	6·62	19	6·72
1956..	316	4·43	166	7·67	42	7·29	25	7·85
1957..	239	4·78	167	8·04	52	6·67	26	6·88
1958..	235	4·58	124	9·37	56	6·70	21	6·86
1959..	256	5·54	115	9·28	39	7·69	19	7·70
1960..	220	5·06	118	8·55	21	7·72	11	6·61

(Figures are taken from the Board of Agriculture statistics; bags refer to 200 lb. net for wheat and maize, 180 lb. for barley and 150 lb. for oats.)

Varieties

The move in varietal popularities in wheat over the last four years is summarized in Table 3. The changes reflect the incidence of rust on established varieties and the impact of newly released varieties. Advice on the choice of varieties is published each season to assist farmers in this respect. (*Vide* "Choice of Cereals for 1960" by G. E. Dixon, published in the Kenya Information Services Bulletin No. 6 of March.)

TABLE 3—WHEAT VARIETY ACREAGES, 1957–60

Variety and Year of Release	Percentages of Total Wheat Acreage			
	1957	1958	1959	1960
Bird Varieties (7) 1959	—	—	4·8	20·8
358 1957	3·0	6·2	10·8	13·7
363 1957	1·1	4·3	9·0	11·1
Sabanero	25·4	9·5	10·7	6·2
Africa Mayo 1959/60	—	—	1·1	5·5
1066	9·6	7·9	9·9	5·2
Baby Equator	12·7	7·9	7·0	4·1
Kentana Yaqui 1960	—	—	—	3·8
362's (4) 1957	7·4	11·1	8·6	2·6
Hopeful 1957	3·4	4·8	2·9	2·0
Wis. 245 x Supremo .. 1960	—	—	—	1·9
Ceres R64 1953	5·5	10·1	2·8	1·8
Mida–McMurachy–Exchange 1960	—	—	—	1·4
131 1939	10·1	3·4	2·9	1·2
Other Varieties	21·8	34·8	29·5	18·7

(*a*) Figures for Baby Equator up to 1958 (inclusive) also cover Equator.

(*b*) Bird varieties are: Curlew, Eagle, Hawk, Buzzard, Quail, Dove and Plover.

(*c*) Sabanero, 1066 and Baby Equator are all pre-war varieties, but re-selected stocks of Sabanero and 1066 were released in 1958 and 1957 respectively. Hopeful is a private importation made in 1951, first approved for general use in 1957.

Before commenting on the picture this year, it is worth recording that 47 wheat varieties have been released in Kenya over the last ten years. However, the data quoted in the table show that over 64 per cent of the 1960 acreage was covered by varieties released in the last four years; to this must be added allowance for those not specifically quoted which are hidden in "other varieties" making an estimated 70 per cent in all. That is the measure of the instability which prevails; it underlines the short life of most varieties and the way fresh varieties have had to be put out in a constant stream to keep wheat production alive.

The table shows clearly how the Bird group of varieties has kept to the fore this year, and that the old soft wheats Sabanero, 1066, Baby Equator and 131 have all continued their decline. Both 358 and 363 increased somewhat and were the most popular choices for the middle altitudes. In terms of quality the hard red varieties have now dwindled to under 3 per cent, of which most was accounted for by R.64. The acreage of certain soft red wheats was almost 30 per cent in 1959, but fell to 14 per cent in 1960. These varieties were made the subject of a price discount, but it is considered that their decline owes more to the higher expectation of yield from other choices than the discount involved. Fortunately the general level of quality of the newer varieties has been higher than that of earlier releases. The combined effect of these two factors has been to improve substantially the general quality picture for the crop as a whole.

Turning now to other cereals, the barley and oat situation remains unchanged so far as varieties are concerned. No new varieties have been issued lately, and the comments made in the report for 1959 remain valid.

Diseases

The report of the Plant Pathologist, which follows this report, covers this subject in full but certain points need comment nevertheless.

Stem rust was late to develop and as a result wheat in the middle and lower ranges of altitude largely escaped serious attack, but where it did flare up, attacks were both widespread and severe. This severity of rust has occurred before, but the problem now to be faced is the wide range of virulence by the rust races concerned. International races 40 and 189 were specifically mentioned last year, and these two races have been dominant in 1960. Their virulence is such that they can attack most of our commercial varieties and their power to destroy wheat in Kenya has been demonstrated only too well in the higher altitudes in 1960. The Bird varieties, for instance, had been widely adopted for these areas this season and had a high yield potential; yields of 12 bags/acre were quite common in 1959 and they averaged 7 bags. Now their average yield for 1960 may be only half this figure, and many fields yielded nothing. From their position at the top of the table of varieties, the Birds must fall now to minor varieties for the very highest districts only. Both 363 and 358 have also been attacked by these races, though fortunately with less serious consequences so far.

The stem rust picture must be underlined now as one of considerable disquiet, transcending all others, and the prospects for 1961 are very worrying. Much will depend on the way the weather develops and how soon a stem rust attack is able to start.

III—Breeding—Wheat, Barley and Oats

Considerable increases in the volume of breeding material on hand were effected both at Njoro and the sub-station for higher altitudes at Molo. The usual range of further observation plots and trials was carried out at district stations to provide wider evaluation of varieties under multiplication.

Some 24,550 plots were grown at Njoro, together with a further 3,300 at Molo, Ol Joro Orok and Perkerra; to these figures were added the general trial and observation programme. In fact this was a two-fold increase in the material for selection over that reported last year and represented an extremely large body of material which strained the handling capacity to the limit. Further collections from the Americas

figured largely in this increase, and once again the value of such international exchanges is strongly emphasized. Whilst acknowledging the receipt of much material, it should be recorded that this co-operation has also led to Kenya material travelling abroad and a large number of Njoro breeding lines are being tested in the Americas. In addition, important collections were sent particularly to Ethiopia and Pakistan this year for comparison with our results in East Africa.

Accessions and Crosses

The difficulties of the drought period of June and July had to be overcome by the use of irrigation, but a build-up of stem rust was considerably delayed by this dry spell. The rains in August and September produced the conditions necessary for rust development and the consequent rust levels resulted in a better screening of material than had been expected earlier.

Further selection within the Mexican and Colombian collections of 1956 to 1959 has reduced the volume of this material considerably; there is now a residual body of lines which show definite promise for the future. Two of the first Colombian lines, BT 1476 and BT 3475, have now reached field multiplication, whilst, in the progeny-row stage, crosses involving Cajeme 54, Wisconsin 245, Frocor and Yaqui stand out particularly well. Two further large collections were received in 1960, comprising 5,145 lines from Chile and 7,973 from Colombia. They included a wide range of wheats but the majority proved either unsuitable agronomically or extremely susceptible to rust and Glume Blotch.

A further smaller but more valuable collection of wheat was obtained from Chile, made up of parents for specific purposes, e.g. rust resistance, yield, straw strength, etc. This collection produced several new and valuable varieties which will be of importance in future Njoro programmes. Notable in this material are several hitherto new wheats of winter, or near-winter habit, which stood up well to stem rust and if crossed with spring wheats in Kenya should produce worthwhile combinations. Also worth special mention are a group of interspecific crosses originally made in the U.S.A. by Dr. W. J. Sando; these remained completely free of stem rust. They are however still far removed from normal wheat types, but will be of special value in a backcrossing programme.

Wheat accessions obtained in more limited personal exchanges between breeders amounted to 43. A group of wheats from the Plant Breeding Institute, Cambridge, from the cross C.I. 12633 x Chinese 166—Lin Calel, were quite outstanding on both stem and leaf rust scores. More of this material is now available for sowing in 1961 and it emphasizes the value of small collections carefully chosen for specific characters.

Rust tests with stock cultures of stem rust were carried out on both seedlings and mature plants from the 1958–59 backcrossing programme, but they gave anomalous ratios with a preponderance of susceptible plants. The readings obtained agree with those mentioned in the 1959 report and the lack of resistant segregates in such a large and widely based programme has proved not only a great disappointment, but remains unexplained. The two most hopeful groups (i.e. the Regent crosses and the 362. B.1.D.3.D. crosses) were grown in the field this year as F_2 bulks of the original crosses, the former at Njoro and the latter at Molo. The Regent group in particular produced a number of useful selections which will be continued as single plant cultures, with the possibility of reconsidering backcrossing to the Kenya parent if resistance is maintained. The three remaining groups of crosses, involving 294.M., 184.P., and 354.P. will now be subject to similar treatment and selection, though the earlier disappointment with this particular programme does not give much confidence in this material. All this means that any move to the production of composite varieties from this material has now receded considerably.

Turning now to new crosses, a further substantial body of crosses was made in 1960 mainly involving the *Triticum timopheevi* resistance of Wisconsin 245 x Supremo, and the Idaho 1877 and 1880 group of lines.

The main body of pedigree breeding lines is too extensive to describe in detail but again certain crosses and backcrosses can be mentioned. Crosses of C.I. 12632 with 261.R., 360.H., R.64., Regent and La Prevision have given excellent material,

and the value of this parent for stem rust resistance cannot be emphasized too strongly; it derives as already indicated from *T. timopheevi*. The double crosses for both stem and yellow leaf rust resistance again bring out the special value of C.I. 12632. In addition, Lagaedinho and C.I. 7805 show to advantage here for their yellow rust resistance.

The search for new barleys was considerably extended this year by the growing of the World Barley Collection of 5,100 entries. The great majority proved unattractive, but a few selections were harvested for further study. In the oat work, selections were made in the crosses of 1959, and it is hoped that the extreme earliness of the French oat Dupree will be of value. In general, the oat importations failed again to resist rust, and hopes of an improvement in the oat varietal situation remain poor.

In concluding this section, two special points for the future can be made. The large collections from overseas represent, for the most part, permutations amongst a known body of material which has been well tested. Whilst further importations must continue, greater value will now accrue from more intensive selection and breeding in the material already collected. Secondly, the special value of C.I. 12632 has been so outstanding in the breeding programme that special priority should continue to be given both to the earlier crosses and to the newer body of related crosses made in 1960. There is rust resistance there which is clearly superior to any other that has been available in recent years; in particular this resistance is effective against both race 40 and 189 which have been mentioned earlier in this report.

Nurseries

Little needs to be added here to the comments made last season. Both the International and F.A.O. series of wheat, barley and oat nurseries were grown at Njoro, with repeat planting of the wheat nurseries at Naro Moru. The special yellow or stripe rust addition to the International Spring Wheat Nursery at Molo, although showing useful resistance to yellow rust, was extremely heavily attacked this year by stem rust; little of value could be estimated.

Few selections were taken from these nurseries in 1960, reflecting the paucity of new entries available for extraction and the exhaustion of resistance to which reference was made last year.

Initial Multiplications

There were 319 multiplications under this head at Njoro, of which certain Minnesota selections of Thetcher type, namely II–53–307, 320, 370 and 486, were specially attractive. The Idaho 1877 and 1880 mentioned last year again performed well, together with the first multiplications of new Kenya material. Multiplications in recent years have almost all been from nurseries and collections, but now more Kenya-bred material is coming forward from the much increased crossing work since 1955.

Particular disappointment was experienced with the multiplications at Ol Joro Orok for the higher country. Forty-four selections based on Frocor were virtually destroyed by stem rust and this set-back, combined with the damage to the Bird varieties in commercial use, means that the supply of varieties for high altitudes will be decidedly limited.

District Trials and Observations

Sixty-five wheats at an advanced stage of multiplication were in a comprehensive programme of district trials in 1960. Of the seven sites involved, Eldoret gave outstanding yields, but Rongai was too droughted to be of value. At the higher sites, widespread lodging followed excellent early growth, and yield results were difficult to obtain.

The variety H.441, and the Minnesota selections II–53–307, 320 and 370 gave particularly good performances on rust resistance, and their yield was satisfactory.

Field Multiplication

There were 32 foundation and mother crops at Njoro and nine at Ol Joro Orok. There were however some losses from rust, and the total going forward next year will be in the region of 24 varieties, of which 8 will be at the pedigree stage with farmers. The outstanding varieties at foundation stage were Kenya 1012.G.2, H.441 from Wisconsin, (Spring Wheat x Gabo) x Lerma from Colombia and the Yaktana 48 x Kentana 48 selections made at Njoro. Amongst mother crops, RL 3207 as a durum for high altitudes and Kenya 599 receive special mention; the latter is one of few selections from the pre-1955 work which has managed to survive the modern range of stem rust races. It is a 360 F x Granadero Klein derivative.

Nine varieties were sown at Perkerra out of season at the end of the year for specially accelerated multiplication.

Release of New Varieties

Five of the varieties mentioned as due for pedigree crops last season were given provisional release for the Short Rains season at the end of 1960. (*Vide* "Release of New Cereals—1960/61" by H. C. Thorpe, in *Kenya Information Services Bulletin* No. 14 of November, 1960.)

Further releases are due at the time of writing and the full list will be published shortly, probably comprising the following seven varieties.

Table 4—Varieties for Release for 1961

Variety and Selection	Origin	Altitude Range
(Aquilera–Kenya x Morroqui–Supremo) x Yaqui^2, (3785–23c–2c–2c)	Mexico	6–7,000 ft.
Kenya 374.Q.7.A.4	Newthatch x 192.Q.2.A.1	6–7,000 ft.
No. 43 (P.I. 159106)	South Africa	6–7,000 ft.
Lee Frontana*, (C.I. 12957)		7,500/8,500 ft.
Veranopolis, (P.I. 21440)		6,500/7,500 ft.
Rushmore–Surpresa, (P.I. 12972)	N. Dakota	6,500/7,500 ft.
Yaktana 54, Selection 2, (P–14–1h–7h–6h)	Mexico	6–7,000 ft.

*Now being withdrawn.

IV—Breeding—Maize

The expansion of maize breeding made possible by the Colonial Development and Welfare Scheme was reported last year, and came into full field operation in 1960. There was considerable increase in the volume of work at Kitale and Endebess, and the opening of the sub-station at Kakamega for related work in Nyanza. The programme for the drier areas continued meanwhile at Machakos, but very little maize work was handled this year at Njoro or the Coast.

Kitale and Kakamega

The drought which severely hit down-country areas was not nearly so serious in the Trans Nzoia. Some areas have badly reduced maize yields, but on the whole the district average is probably a little above the mean. It has been a good wheat year in Western Kenya. For the second year running the Endebess maize trials were badly damaged by hail. It is now the policy not to run any trial at only one site but both the Endebess locations were hit. However, sufficiently valid results can probably be obtained to select lines for forming into the first Endebess synthetic in 1961.

The basic breeding plan, producing both hybrids and synthetics in a joint co-ordinated scheme continued, reaching Year 8 at Kitale, Year 4 at Endebess and Year 1 at Kakamega. The new cycle was started at Kakamega by making 1,000 selfings

in four open-pollinated varieties previously found to yield best at Kakamega. A new cycle was also begun at Kitale with Kitale Synthetic II as the starting point. Here, as well as 1,000 selfs, 2,000 plant x plant crosses were made to begin a study of synthetic breeding methods. At Kitale there were 251 top-cross plots, 141 selfing plots, 189 sub-bulking plots and at Kitale and Endebess together a total of 4,400 trials plots. At Kakamega there were about 1,300 trials plots, mostly for local evaluation of lines and from materials that have proved good elsewhere. The new accessions resulting from the visit to America last year at first showed good promise but, as the season advanced, serious defects developed, mainly leaf disease susceptibility, poor stalk strength and barren plants. Nevertheless, a number of inbreds and varieties from Central America are better than all previous accessions from any other country and it is still hoped to produce good crossing values to local lines from some of these.

At the time of writing few trials results are analysed. It is too early yet to say whether Kitale Synthetic II has repeated its excellent performance of last year in the series of ecological trials run at six locations covering the West of Rift area. Preliminary figures, however, show that its release is justified. Bulking has given good yields on four farms growing 100 acres each but demand for selected seed will greatly exceed supply and rationing will be needed. In North Nyanza District it has given good increases on fields yielding well, but on poor fields it yielded less than local seed; the average yield in this district is so low that release there is not advisable. In a trial at Songhor, synthetic maize has given twice the response to nitrogen shown by farmers' stocks. The picture emerging is that Kitale Synthetic II is an improved variety capable of yielding better under good fertility and generous fertilizer application, but that under poor conditions it cannot be recommended.

Njoro

The dry conditions and differences in planting dates led to anomalous results with the Njoro Synthetic II. In the ecological trial it exceeded Synthetic I satisfactorily, yet in a special comparison trial of these two maizes the Synthetic I significantly out-yielded Synthetic II at 22·6 bags to 19·7 bags/acre respectively. Further trial in a more normal season is now needed before any decision on this maize can be reached. Meanwhile further material was under trial for the possible formation of a third synthetic; results of this are awaited.

Katumani

Further small releases of Taboran maize were made to Machakos district growers during 1960. Although this maize proved popular, few growers made an effort to bulk or save Taboran seed and it is clear that a large-scale bulking and distribution scheme will be required if any lasting impression is to be made on the dry areas as a whole.

Analysis of trials over five seasons from Katumani (5,300 ft.) and the lower hotter areas of Machakos (3–4,000 ft. represented by Makueni, Kikumbulyu and Kibaoni) has proved instructive. These trials have compared yields of Taboran and Local White maizes at various populations. Paired yield data have been taken from each trial and correlations worked out between them. For Taboran, comparing 3 ft. x 1 ft. (14,500 plants/acre) and 3 ft. x 2 ft. (7,260 plants/acre), a highly significant correlation is obtained and it is found that the advantage lies with the 3 ft. x 1 ft. spacing for all yield levels above 300–400 lb./acre. For Local White, a similar good correlation is obtained, though here the 3 ft. x 2 ft. spacing is superior at yield levels below 1,000–1,200 lb./acre. For a comparison of the reliability of yield of the two maizes, the Taboran 3 ft. x 1 ft. yields were correlated with corresponding yields of the local maize at both 3 ft. x 1 ft. and 3 ft. x 2 ft. spacings. The overall picture is that Taboran is superior at all yield levels below 2,000 lb./acre. There appears to be a difference between high altitude and low altitude trials; at Katumani the superiority of Taboran is less marked, whereas at lower altitudes Taboran is superior over an extended yield range.

Assuming that yield is limited by rainfall, and knowing the seasonal expectation of rain and the yield x rainfall relationship for the two maizes, the relative advantages of the two maizes in a certain rainfall area can be assessed. For the dry areas of

Machakos, the greater reliability of yield of Taboran over the Local White is firmly established, and at Katumani an advantage can be expected from the former in five or six seasons out of ten.

Further advantages of a short-term maize such as Taboran have come to light. There appears to be a considerable indirect advantage due to the effect on subsequent crops, as regards both time of planting and available subsoil mixture. At Katumani, Taboran planted in the November rains will be harvested in time for a further planting in early March; with Local White this is not possible, and a reduction in yield of the Long Rains crop is to be expected. Also, trials have shown Taboran to exhaust the soil moisture to a lesser extent than Local White, and this can have a big effect on the yield of the subsequent crop.

Trials are continuing with the new Early Synthetic maize; though not as early as Taboran, it could prove most useful to growers in the slightly wetter areas of Machakos. However, efforts to bulk Early Synthetic have so far proved unsuccessful and here again an organized scheme is required.

On the breeding side, difficulties have occurred in selection against white blight, and the next synthetic to be formed from lines derived from Taboran crosses is not expected to show any improvement in blight resistance. However, selection from within the Early Synthetic could possibly solve this problem, and this aspect is already under study.

The sorghum/maize reliability of yield comparison has been transferred to Makueni, which is more suited ecologically to sorghum than Katumani. Using the short-term sorghum TADA and Taboran maize, and protecting the sorghum from bird damage, the big potential advantage of sorghum over maize has been demonstrated. In two poor rainy seasons, TADA has given yields of 1,211 and 1,948 lb./acre compared with Taboran yields of 419 and 1,175 lb./acre respectively. Unfortunately, the problem of combining bird resistance and palatability in sorghums has not been solved and remains the major obstacle to sorghum growing in Machakos district.

Coast

The use of the stock resistant to *Puccinia polysora* was continued in the Shimba Hills district, and a further supply of pure seed is being multiplied at the Tana Irrigation Scheme at Galole.

V—Other Investigations

Wheat Identification

One of the recent responsibilities of the Plant Breeding Service has been to describe and identify wheat varieties on their grain characters. This task has become important in recent years since Government decided to impose a price differential on certain varieties in relation to their baking quality.

When it is realized that 83 varieties are grown to a greater or lesser extent in this country, the magnitude of the task can be appreciated. In point of fact the number of varieties which are commercially significant is about 30, but this still gives a considerable range that must be studied for recognition purposes. A system of identifying wheat varieties was worked out in 1958 and published as "Identification of Red Wheat Varieties in Kenya" by F. F. Pinto and H. C. Thorpe, printed by the Government Printer, Nairobi, 1959. This system has just been extended to cover all the red wheats currently grown; so far no comparable study of white wheats has been necessary as no price differential has been applied to white varieties. The identification system is based upon the recognition of each variety by a phenol staining test in conjunction with a study of the morphological characters of the wheat kernel.

The practicability of the system has been proved during the last three years during a series of short courses on wheat recognition at Njoro. The Wheat Board was responsible for initiating these courses, intended for personnel from the grain mills, wheat stores and the K.F..A who are concerned with the identification of wheat varieties. So far six separate courses have been organized and 34 participants trained in the techniques of grain identification.

The task of identifying wheat varieties is not an easy one, and it must be recognized that to keep abreast of the changing pattern of varieties year by year requires constant study and repeated revision of all the data. The work has in fact become a heavier commitment than was generally recognized when first conceived.

Wheat Quality

The Plant Breeding Service continued to assist in these investigations carried out jointly with the Soil Chemistry Section, and with E.A.A.F.R.O. and Unga Ltd. Work has been mainly on the chemistry side and no specific comments will be made in this report.

With the purchase of a micro-mill and some subsidiary equipment, quality studies on breeders' material are now being initiated in support of the main wheat programme at Njoro.

Other Crops

Assistance has been given to staff of the field services in the selection of various crops, particularly of beans, cowpeas, grams, castor beans and pigeon peas at Katumani, of sunflowers and castor beans at Kitale, and of pyrethrum and rice from Njoro.

VI—Acknowledgements

The co-operation given to this section in 1960 by the staff of Unga Ltd. is acknowledged with special gratitude. Again, our indebtedness to the International Co-operation Administration of the U.S.A. and the Rockefeller Foundation must receive further acknowledgement following their travel awards made in 1960. To the many contributors of collections and breeding material a further debt is recorded.

G. E. DIXON,
Ag. Senior Plant Breeder.

ANNUAL REPORT OF THE PLANT PATHOLOGIST (PLANT BREEDING), 1960

General

1960 was the first full year in which the cereal rust work in Kenya was supported by Colonial Development and Welfare Funds. Development of the pathology section under the new scheme went ahead steadily, the largest single improvement being the construction of a large greenhouse for rust tests. This house greatly increases the amount of bench space available and has made it possible to move all the more critical work out of older accommodation where conditions of light and temperature were unsuitable.

Identification of Races of Wheat Stem Rust

The main effort of the section was again concentrated on wheat stem rust and in particular on the rust race survey, which continued at a high level; a total of 296 samples were collected during the year. With the experience gained in the past three years, it is now intended to reduce the volume of the survey in favour of other aspects of the work. At the same time sampling will be concentrated on those varieties to which special importance is attached, particularly those with good rust resistance.

The desirability of changing from the "Kenya" system of rust race identification to that used in other parts of the world has been felt for a number of years. The main obstacle has been the difficulty in obtaining supplies of the appropriate differential wheat varieties as these are of winter habit and consequently cannot be grown at Njoro. Past work has therefore had to be limited to occasional cross checks of the "Kenya" races on the international differentials. It is now possible to obtain regular supplies of the international differentials from the United States Department of Agriculture and so the Kenya work has now been converted to the international system, with the addition of other varieties as supplemental differentials to distinguish local sub-races. Experiments to select suitable supplementals are still in progress.

The potential danger of race 189 which was stressed in the Annual Report of 1959 was to some extent borne out in 1960, as this race built up very strongly early in the year in the Naro Moru area and in the Northern Province of Tanganyika which is included in this survey. Although it declined in importance towards the end of the year, it nevertheless accounted for almost 30 per cent of the year's samples. The other very dangerous race, 40, and in particular the Kenya sub-race 40C, was also very active during the year; there are indications that there may now be more than three sub-races of this race. Races 40 and 189 are both able to attack a very wide range of wheat varieties and make the search for rust resistance particularly difficult. A previously unrecorded race, first identified in Kenya in 1959, was isolated from 8 per cent of the collections made in 1960 and may well prove troublesome in the future. No international number has yet been assigned to this race. Race 14 occurred during 1959 but was not identified in 1960. Races 21 and 42 declined sharply during the year. The frequency with which races occurred during 1960 is shown in the table below, based on the 216 results available up to the time of writing. The figures for 1958 and 1959 are included for comparison.

Attempts to establish the usual rust epidemic in the breeding plots at Njoro were largely unsuccessful because of the very dry conditions. It is proposed to try an oil-spray method of inoculation in place of the present technique of injection by hypodermic needle. Difficulties in establishing a satisfactory epidemic for field screening and doubts as to the validity of seedling tests as an indication of adult plant resistance, point the need to develop a reliable screening technique. Increased attention will therefore be given to this problem in future.

TABLE 1—PERCENTAGE FREQUENCY OF STEM RUST RACES, 1958–60

International Race	Kenya Race	Number of Isolations (Percentage of Total)		
		1958	1959	1960
11	—	—	6·0	8·1
14	—	—	0·3	—
21	K12	18	14·7	1·7
24	?	—	0·7	0·6
34	?	—	0·3	6·3
40A	K16	20	11·7	10·4
40B	K17	6	3·0	2·3
40C	K18	16	19·7	16·8
40 Sub-race not yet determined		—	—	9·2
42	K13	10	23·3	2·9
143	K14	16·5	9·7	2·9
184	—	—	0·7	1·2
189	K19	13·5	9·3	29·5
New Race	—	—	0·7	8·1

NOTE.—In the table, two or more isolations of the same race from a set of experimental plots at a single site are treated as one record only. All isolations from farm crops are considered separately.

RUST EPIDEMIOLOGY

A number of projects are in hand which are aimed at giving a better understanding of the stem rust organism in Kenya.

The role of grasses in the perennation of the rust fungi is a subject of special interest. Numerous collections of rusts on grasses have been made during the year and inoculated onto wheat and oats. Positive results have included wheat stem rust on *Bromus diandrus*, *Lolium temulentum* (Darnel) and *L. rigidum* (Wimmera rye grass): oat stem rust on *Dactylis glomerata*, *Phalaris caerulescens* and *P. tuberosa* and yellow rust on *Bromus montaneum*. This work will be continued and it is unlikely that the present list is exhaustive, but the results obtained are already highly significant. Investigations on the indigenous barberry (*Berberis holstii*) as a carrier of cereal rusts have continued, but attempts to infect wheat with rust from the barberry have failed. Seedlings of *B. holstii* grown in the United States from seed sent from Kenya were however shown to be susceptible to wheat stem rust. A Hirst spore trap was operated throughout the year at the Plant Breeding Station; spore counts are not yet complete, but numbers were generally surprisingly low and indicate the importance of build-up of rust within a crop rather than mass bombardment from outside sources.

YELLOW RUST (*Puccinia glumarum*)

Further samples of yellow rust were sent to Germany for race identification during the year but results have been disappointing. Very few samples arrived in a viable condition and it seems that future work will have to be done at Njoro, despite the need to build special air conditioned accommodation for this work.

OAT STEM RUST (*Puccinia graminis avenae*)

Race identity tests on 46 samples of oat stem rust revealed the presence of four races in Kenya. These include 6, 6A and 13A and a further race which has not previously been recorded and to which no number has yet been assigned. Races 6A and 13A are recognized internationally as being particularly damaging and the new race seems comparable; jointly their presence in Kenya explains the severe rust attacks which oats commonly suffer.

CEREAL DISEASES AND ADVISORY WORK

Stem rust levels varied sharply during the year. Heavy attacks on the Short Rains crops at the beginning of the year caused considerable damage, but dry conditions in the early Long Rains crops kept rust levels down and yields were high. Return of the rains in September and October brought extremely damaging rust attacks in the later high altitude areas and heavy losses were suffered, especially by the "Bird" group of varieties. As the race mainly responsible (race 40) has been present in Kenya for some years it must be concluded that the particularly severe attack was the result of the climatic conditions rather than a change in the rust organism. Damage from brown leaf rust (*P. recondita*) was generally light, but yellow rust (*P. glumarum*) was heavier than usual particularly in the ears. Ear rust was unexpectedly high in the "Bird" varieties, and this group also suffered considerable yield losses as a result of attack by *Pyrenophora tritici-repentis.*

Septoria tritici and *S. nodorum* ("glume blotch") were both above normal, and the late rains resulted in extensive discoloration of the ears by saprophytic fungi, especially *Cladosporium herbarium.*

Take-all (*Ophiobolus graminis*) was rather more damaging than has been the case in recent years.

E. J. GUTHRIE,
Plant Pathologist.

ANNUAL REPORT OF THE COFFEE RESEARCH STATION, RUIRU, 1960

In many respects the weather of 1960 in the coffee areas was remarkably similar to the previous year. After a normal dry season the Long Rains broke on time during the third week of March. In the East of Rift districts rainfall was heavy for some weeks, but early in May the rains ended abruptly a month prematurely. Dry and abnormally warm conditions ensued for nearly six months until the Short Rains brought relief at the end of October. After one of the most prolonged dry periods recorded for many years the rains were again unusually brief, lasting but three weeks and tailing away earlier than normal. Set against these conditions the salient feature of the year was an unusual proportion of early crop, brought about by a similar but less severe weather pattern during 1959 which led to heavy flowering at the end of the year. Owing to the prolonged dry weather much of the early crop came to ripeness prematurely, with size and quality adversely affected. The quality of the late crop was similarly affected by drought and, as in 1959, most of the new wood was sufficiently mature to bear flower in November. Undoubtedly the value of well-distributed rainfall can be most readily appreciated in such years when it is absent.

In the Rift Valley and West of the Rift conditions approached the normal pattern in most districts, although rainfall in April and May was lower than average.

Leaf Rust infections were generally less severe in all areas than in recent years, due to the distinct dry seasons and relative absence of unseasonable rainfall. A similar situation prevailed with Coffee Berry Disease, although the level of infection was more variable. East of Rift the disease was at a relatively low level until infection built up during the Short Rains.

RAINFALL AT THE COFFEE RESEARCH STATIONS DURING 1960

Inches per month	A	B	C	D	E	F	G	H
January ..	0·75	1·79	0·26	0·10	4·82	2·68	0·72	6·30
February ..	0·46	0·00	0·43	2·72	4·31	0·73	0·82	0·82
March ..	9·72	7·94	7·34	7·11	11·41	13·08	12·94	9·42
April	10·05	6·50	4·35	3·34	10·11	9·61	15·93	7·72
May	1·75	2·34	1·59	3·16	6·46	2·09	0·68	6·48
June	0·31	1·30	0·14	4·24	3·90	0·82	0·58	1·99
July	0·64	0·34	0·23	5·15	1·82	1·06	0·34	1·63
August ..	0·29	0·43	0·03	5·88	3·81	0·85	0·28	5·44
September ..	0·68	0·60	0·17	4·39	9·91	1·23	0·20	3·84
October ..	3·34	3·97	5·61	1·97	4·62	3·69	12·21	2·48
November ..	7·66	2·78	3·53	1·35	5·26	9·02	9·13	2·77
December ..	1·23	1·78	1·73	1·85	2·46	0·76	7·97	2·53
Total	36·88	29·77	25·41	41·26	68·89	45·62	61·80	51·42
No. of days ..	103	104	69	165	214	127	129	148
Means and number of years	38·85 16	37·19 35	36·63 21	45·41 27	72·97 17	—	—	—

A = Coffee Research Station, Ruiru.
B = Scott Agricultural Laboratories, Kabete.
C = North Kitito Estate, Makuyu.
D = Kitale Experimental Station.
E = Kisii Coffee Research Substation.
F = Upper Kiambu Coffee Research Substation.
G = Mariene Coffee Research Substation.
H = Koru Coffee Research Substation.

Leaf miner continues to present the pest problem of greatest importance throughout the coffee growing areas. Research on the problem was greatly augmented in the latter part of the year by the arrival of Dr. Bess, Senior Professor of Entomology at the University of Hawaii (on a nine months' Fulbright Scholarship), and by the arrival of Mr. P. E. Wheatley as second Entomologist, in November. Dr. Bess has focused most of his attention upon the bionomics of Leaf miner with particular reference to the relation of chemical control to parasitism. Research on other major pests has continued, with some useful progress being achieved: study of the biology and/or checks upon estate control measures have led to a better measure of control of White Waxy Scale, Star Scale, Tip-Stem Borer and Yellow-headed Borer.

The salient points in the work of the Plant Pathologist were a co-operative project with Mr. Wallis on the use of low-volume sprays for the control of Leaf Rust, further work on the stem-pitting condition and initial investigations of nematode infestation of coffee nurseries.

In his research on coffee physiology, Dr. Wormer has continued his carbohydrate studies as the main project. Interesting progress was made in studying the water relations of the tree and on leaf fall. In collaboration with the Plant Pathologist the conditions known as "Hot and Cold" and "Crinkle Leaf" have received attention, their symptom patterns being defined and experiments initiated, designed to reveal the causes of each.

The research programme into soil fertility and plant nutrition problems was continued, but on a reduced scale after Mr. Robinson, the Agricultural Chemist, departed in March on transfer to the Coffee Research Station, Tanganyika.

Field investigations, of necessity, cover a wide field of cultural problems, on both the main station at Ruiru and on the seven substations listed in the Table of Rainfall data. During the year the range of field experiments was increased on all stations, particularly upon the four substations which have been established since 1957. In view of the dry conditions East of the Rift during the past two and a half years and the widespread Leaf Rust outbreaks which have affected coffee for the past five years, interest has centred on the irrigation experiment at the Coffee Research Station and studies of low-volume spraying for Leaf Rust control, with useful progress being made during the year on both projects. As in 1959 results from the Variety Trial programme were of special interest, an increasingly important factor being Leaf Rust resistance and its relevance to coffee development in the lower zones of the African areas.

The programme of coffee processing research was devoted to four main lines of work. Mr. Gough continued his experiments on methods of utilizing ventilated bins and on the relation of the stage of cherry ripeness to quality. Mr. I. M. Johnson (Agricultural Engineer) at Nakuru made further progress with the problem of drying coffee in the initial stage after final washing. Mr. A. E. Wootton, E.A.I.R.O., continued his research into the causes of onion taint and is due to report the results of his investigations in March, 1961.

A fully detailed record of all research undertaken during the year is included in a separate report covering the 1960/1961 crop year. As in the previous four years copies of this report, published in July 1961, are obtainable from the Coffee Research Station, Ruiru.

P. A. JONES,
Senior Research Officer.

ANNUAL REPORT OF THE ENTOMOLOGIST (COFFEE SERVICES), 1960

In the coffee areas East of the Rift Valley, Leaf Miner was by far the most important insect pest in 1960, particularly during the last three months of the year. Lacebug caused less damage than in any other year since 1956 when it first appeared in the East Rift, whilst the only leaf-eating pest to cause widespread damage was Stinging Caterpillar. In West Rift areas, Antestia remained the dominant pest, and some outbreaks of tailed Caterpillar were reported. Only one Leaf Miner species *Leucoptera meyricki* Ghes. has been found in the West Rift and rarely causes serious damage.

The research programme during the year was largely one of consolidation, several small projects being taken to, or near the point where they can be written up for publication.

Leaf Miner *Leucoptera meyricki* Ghes. and *L. caffeina* Washb.

No insecticide has yet come to hand that appears likely to displace Parathion, Methyl Parathion or Diazinon for the control of larvae within mines.

Twenty-eight species of Hymenoptera have now been bred from the two *Leucoptera* spp. and of these all those not yet named have been sent to the British Museum for identification. A list of *Leucoptera* parasites found in East Africa will be published in co-operation with the Entomologist, Coffee Research Station, Lyamungu, Tanganyika.

A special study of the integration of biological and chemical control of coffee pests is being made by Dr. Bess, during his nine months Fulbright Scholarship at the Coffee Research Station. The study was begun in September 1960 and involves weekly measurements of the population of pests, especially Leaf Miner, and their parasites in sprayed and unsprayed coffee. The findings so far indicate that insecticides kill Leaf Miner more readily than the parasites inside the mines. There are several complicating factors, such as the proper timing of spray applications. There are good indications that parasitization may be increased through the judicious use of certain insecticidal sprays.

Antestia *Antestiopsis lineaticollis* (Stal.)

A full account of the pyrethrum/D.D.T. method of control has been accepted for publication in the *Bulletin of Entomological Research* and will probably appear in 1961. A brief account of the method appeared in the June 1960 number of *Kenya Coffee*. Gelatine capsules containing 5 ml. of 10 per cent Pyrethrum and 10 per cent synergist became commercially available during the year. One capsule in one pint of kerosene was found to be fully equal to the home-made "double strength" pyrethrum extract used in the past.

White Waxy Scale *Ceroplastes brevicauda* Hall

The main points in the life history of this scale have been elucidated. There are two generations a year at Jacaranda, maturity being reached during the main rainy seasons. Eggs are found under the carapace of the scale; on hatching the crawlers take up a position on mature leaves, mostly along the main veins. The first two instars are passed here. The scales then migrate from the leaves to adjacent green shoots where they remain for the rest of their life.

The scale can be controlled if detected while still on the leaves; July and February are normally the best months for spraying. 2½ per cent white oil and Malathion 0·15 per cent a.i. have proved effective as high-volume sprays against the first two instars.

Star Scale *Asterolecanium coffeae* Newst.

Treatment of affected bark with 5 per cent Tar Oil has given excellent control on an estate scale, although it has been found essential to apply Tar Oil only on a hot dry day to facilitate good absorption by the bark. Scales feeding on primaries are not treated but are quickly cleared up by parasites.

Lacebug *Habrochila ghesquierei* Schout.

Work in Uganda has clarified the confusion between *H. ghesquierei* and *H. placida*. The former appears to be normally confined to *Coffea arabica*. Since observations in the literature on the life history of *H. ghesquierei* are suspect, further field studies are being made at Ruiru. The egg period has been found to vary from 18 to 32 days and the nymphal period from 16 to 36 days. In addition, a pre-oviposition period of over 7 days has been observed. When the observations have been completed, revised spray timing recommendations will be issued.

Sprays of 0·02 per cent Parathion have given excellent control of nymphs and adults. Lacebug has not yet extended its range into the Meru and Machakos districts.

Green Scale *Coccus alpinus* De Lotto.

Identities of green scales occurring on coffee in Kenya have been clarified by De Lotto. The common species infesting *Coffea arabica* has been described as *C. alpinus*, a new species. A further new species *C. viridulus*, was collected from *C. arabica* in the Nandi Hills.

Leaf Skeletonizer *Leucoplema dohertyi* Warr.

A short account of its biology was published in the July 1960 issue of *Kenya Coffee*.

Berry Moth *Thliptoceras smaragdina* Butler

Routine trapping of this species continued at Makuyu, but no large build-up occurred during the year.

Tip Borer *Eucosma nereidopa* Meyr.

Counts continued during the year at several sites at Upper Kiambu and confirmed that 2 per cent D.D.T. applied to the trunks of shade trees gave an excellent and economic control.

Yellow-Headed Borer *Dirphya nigricornis* (Ol.)

The pyrethrum/kerosene mixture used for Antestia test spraying has been found to give good control of larvae when injected into their tunnels. A full account of the biology and control of this pest has been written and will probably appear in print during 1961.

Mites

Four species of phytophagous mites have now been recorded from coffee in Kenya. These are *Oligonychus coffeae* (Nietner), *Brevipalpus phoenicis* (Geijskes), *Hemitarsonemus latus* (Banks) and *Diptilomiopus* sp. There is no evidence yet that any of them cause economic damage. Current information on these four spp. was summarized in an article in the December 1960 issue of *Kenya Coffee*.

Taints

There are several reports of "bricky flavour" occurring in coffee from the Thika and Fort Hall districts during the year. The cause appeared to be drift of BHC sprays from aircraft spraying a swarm of Desert Locusts.

Reports of "grassy flavour" are being investigated as they occur. Similar off-flavours in other countries are spread by insects. To date, the reports of "grassy flavour" have been too few to enable a thorough investigation to be made.

P. E. WHEATLEY,
Entomologist (Coffee Services).

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (INVESTIGATIONS), 1960

Mulch Trials

The benefits of mulching have been particularly evident during 1959 and 1960 when the rainfall has been poorly distributed. A review of mulch trials on the Coffee Research Station shows that coffee of all ages, whether pruned on the single or multiple-stem system, has responded beneficially to the application of mulch. Some results are summarized in Table I.

Table I—Responses to Napier Grass Mulch
1960 Yield in Cwt. Clean Coffee per Acre

Trial	Pruning system	Mulch (March)		No mulch yield	Response to mulch	Level of significance
		Laid in	Yield			
Coffee planted before 1920						
1	Single stem ..	Alternate interrows ..	7·76	6·08	+1·68	N.S.
2	Multiple stem	*a.* All interrows ..	13·59	6·78	+6·81	p=0·001
		b. Alternate interrows ..	11·17	6·78	+4·39	p=0·001
Coffee planted in 1956						
3	Multiple stem	Alternate interrows ..	5·53	2·63	+2·90	p=0·001
4	Multiple stem	Alternate interrows ..	12·00	7·61	+4·39	p=0·001

In the first trial shown in the table a high degree of variation (C/V = 24·4 per cent) in 1960 accounts for an apparently considerable response not reaching significance. The mean yields over the seven seasons 1954–1960 show a highly significant mean response to mulch of approximately 1½ cwt. of clean coffee per acre per year.

In the remaining three trials the response to mulch in 1960 has been most marked; in the case of Trial 2 (treatment *a*) and Trial 3 it has exceeded 100 per cent yield increase.

Table II—Mulch and Nitrogen Responses
1960 Yield in Cwt. Clean Coffee per Acre

Lb. nitrogen per acre (as A.S.N.)	Alternate interrows mulch	No mulch	Effect of mulch	Level of significance
Nil	12·74	9·87	+2·87	p=0·05
46	11·79	6·24	+5·55	p=0·001
92	11·46	6·71	+4·75	p=0·001
Mean	12·00	7·61	+4·39	p=0·001

The results given in Table II reveal an unusual interaction between nitrogen and mulch. Where there was no mulch the application of ammonium sulphate nitrate at 46 lb. nitrogen per acre reduced the yield of clean coffee per acre by 3·63 cwt. (p=0·01) and at the higher rate of 92 lb. nitrogen the reduction in yield was 3·06 cwt. (p=0·05). In the presence of mulch there was no significant effect of nitrogen fertilizer although the highest yield was recorded in the absence of the fertilizer. These results are given because they are unusual but should not be taken to imply an alteration in current recommendations to coffee growers.

The interactions between mulch and fertilizers have given rise to conflicting evidence for many years and no clear picture has emerged during 1960. It is interesting to note that trials on coffee planted in 1956 (from which two crops have now been harvested) there has been no response to nitrogen fertilizers while exceptionally large yield increases have resulted from mulching.

The use of magnesium fertilizer, as a practice complimentary to mulching, has been advocated for several years and is widely adopted by growers. Notwithstanding visible evidence that foliar or ground applications of magnesium fertilizers can reduce the incidence of magnesium deficiency symptoms on the older coffee leaves, recorded trials have so far failed to reveal any crop response to magnesium fertilizers. Some representative results are given in Table III.

TABLE III—MULCH AND MAGNESIUM RESPONSES

Cwt. Clean Coffee per Acre per Annum

Period	Lb. Magnesium per acre per annum	Mulched		Effect of Magnesium	No Mulch		Effect of Magnesium
		+Mg	−Mg		+Mg	−Mg	
1957–1960 ..	50	12·29	11·68	+0·61	9·95	9·32	+0·63
1958–1960 ..	80	10·71	10·29	+0·42			
1959–1960 ..	100	10·95	10·43	+0·52	7·85	8·22	−0·97

No effect of magnesium is statistically significant.

These results are difficult to interpret but it is clear that any benefits from magnesium fertilizer must be slight if they are not apparent after five years of application and four years of yield recording (i.e. the first trial shown in Table II).

J. A. N. WALLIS,
Agricultural Research Officer.

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (RESEARCH), COFFEE LIAISON (AFRICAN DISTRICTS), 1960

A vast amount of information, mostly of an observational nature, has been obtained during recent years from the large number of Coffee Variety Trials distributed throughout the African Areas. In many Districts sufficient knowledge has now been obtained, relating to cropping potential, disease resistance and liquoring quality of various coffee varieties, to recommend with confidence the variety most suited to a particular climatic area.

Between 5,200 ft. and 6,000 ft. throughout Central Province, the high-yielding and excellent quality liquoring varieties SL28 and SL34 have been outstanding. The variety SL34 is preferred for planting at higher altitudes approaching 6,000 ft. where the growth and leaf abnormality known as "Hot and Cold" usually occurs. In the localities between 5,200 ft. and 5,700 ft. SL28 is particularly suitable and has been outstanding in the Meriga Mieru (Meru District) Variety Trial (5,500 ft.); here an average yield per year of 19·40 cwt. of clean coffee has been obtained since 1954.

In the Leaf Rust (*Hemileia vastatrix*) endemic areas of Nyanza Province (below about 5,400 ft.), in Central Province (below about 5,200 ft.) and in Coast Province (Taita District below 5,400 ft.) the ability of varieties to resist Leaf Rust is of paramount importance. Where only Race II of Leaf Rust occurs the varieties K7 and SL6 have been outstanding in Variety Trials; seedlings of both these varieties are now being planted extensively. A far more complex situation exists in areas where both Race I and Race II of Leaf Rust occurs. Several of the Indian S and BA series are known to be immune to Race I and II of Leaf Rust, but insufficient information on potential yield and liquoring quality is available at present to permit recommending the planting of these varieties on a commercial scale. Trees of the same variety of these S and BA selections, grown from seed obtained from the Coffee Research Station, Balehonnur, have shown great variability in variety trials; consequently some reselection will probably prove necessary before release for commercial use.

Where Coffee Berry Disease (*Colletotrichum coffeanum*) is widespread and is known to cause heavy crop losses, the variety Blue Mountain is advised because of its resistance, albeit of limited degree, to the disease. In South Nyanza District only Blue Mountain is planted above the 5,600 ft. level. Although other varieties, such as SL28 and SL34, have a heavier cropping potential their yielding ability cannot be realized unless a full programme of Anti-Coffee Berry Disease sprays is efficiently applied. Throughout many African coffee areas the difficulties associated with applying high volume fungicidal sprays at frequent intervals are nearly insuperable. Moreover the economics of such sprays in parts of Nyanza Province of difficult terrain would require detailed study.

B. F. HANGER,
Agricultural Research Officer.

ANNUAL REPORT OF THE PLANT PATHOLOGIST, COFFEE SERVICES, 1960

Leaf Rust

Hemileia vastatrix has been recorded on Robusta Coffee for the first time in Kenya. In November specimens were received from Samia Location, Central Nyanza and in December from Busia, North Nyanza. This fungus (presumed to be Race IV) is present in Uganda from where it has probably entered Kenya. Specimens received so far have not been sufficiently viable for race screening in the laboratory at the Coffee Research Station.

Comparative fungicide field trials for leaf rust control have been concluded. Burgundy mixture and 50 per cent formulations of cuprous oxide and copper oxychloride remain the standard recommendations. Further comparative fungicide trials should be postponed until more is known about dosage and distribution requirements for leaf rust control. The numerous products now available locally cannot possibly all be tested in field trials and future work will give priority to more basic work on rates and concentrations required for effective rust control.

A preliminary experiment, comprising low, medium and high-volume copper spraying at various concentrations, has indicated that adequate control of Leaf Rust can be achieved with less than 10 gallons of spray fluid per acre. This has confirmed the view that improved control is achieved more readily by increasing fungicide concentration rather than spray volume per acre. Further experiments to confirm these results and to translate experimental low-volume spraying to practical field recommendations are in progress.

Soil Fumigation

It has been observed that there is a general loss of seedling vigour in coffee nurseries, which have been in use for several years continuously, which is not attributable to a decline in soil fertility or structure. Marked stimulation of growth of seedlings has been produced following soil fumigation treatment. Seedlings from fumigated beds had tap roots twice the length of seedlings from control beds, and the lateral roots were more extensive. Difference in height and stage of development of the aerial parts were also considerable. Although high numbers of free-living parasitic nematodes are found in nurseries, where loss of seedling vigour has occurred, the importance of their possible role in causing root damage has not yet been established.

Seedling Disease

A coffee seedling disease affecting plants suffering various adverse conditions has been associated with infection by *Fusarium oxysporum*, which attacks the stem just above ground level. Healthy seedlings do not appear to be susceptible and artificial inoculations with the fungus have not succeeded in producing the disease, although the fungus can be recovered from the wood several months later. This confirms observations in the field, which have strongly suggested that only plants which have suffered from drought or other setbacks suffer from the disease.

I. D. FIRMAN,
Plant Pathologist.

ANNUAL REPORT OF THE PLANT PHYSIOLOGIST (COFFEE SERVICES), 1960

Growth Recording

The growth recording at the Scott Agricultural Laboratories was discontinued in March and also concluded at the Coffee Research Station in November. As in previous years, growth was closely related to the rainfall pattern. The shaded trees grew more than the unshaded and the multiple-stem trees were ahead of those on the single-stem system. Stripping of crop had very little effect apparently.

Carbohydrate Studies

In January the first of a series of monthly samplings was taken from the experiment, designed to study levels of carbohydrate and mineral elements in various parts of the tree. The experiment will be continued in 1961, thus covering two cropping cycles. A full discussion of results cannot be presented until the observations are complete.

Visual scoring of starch in branches of multiple-stem coffee is now being carried out as an additional method for studying the deposition and depletion of food reserves of the plant, thus extending these studies beyond the limited facilities of chemical analysis. The problems investigated comprise the importance of foliage density, the amount of crop and the contribution secondaries make to the food reserves of the tree. Part of the observations is duplicated by chemical analysis in order to test the accuracy of the visual scoring.

Water Relations

Pot experiments confirmed the earlier observation that an important water deficit in leaves arises only when the soil is close to the permanent wilting percentage. Measurements of stomatal aperture showed that, according to weather conditions, stomata might start to close even when the soil is near field capacity; even so they can also remain full open until half or more of the readily available water has been lost.

Growth measurements and readings of stomatal aperture were begun in the Irrigation Trial, in order to obtain basic knowledge of the influence of an artificial water supply on the tree.

Leaf Fall

When chemicals were used in concentrations, known to be effective in delaying abscission under laboratory conditions, they failed to show any action on potted plants. The concentrations found suitable in the laboratory were rather low—e.g. 2,4–D and 2,4,5–T at 5–25 p.p.m. Further work is planned to determine the upper limit beyond which the familiar symptoms of damage occur.

"Hot and Cold" and "Crinkle Leaf" Condition

Much confusion still exists on the differentiation of symptoms of the "Hot and Cold" and "Crinkle Leaf" conditions although this can easily be avoided by careful observation. "Hot and Cold" symptoms consist of a yellowing of the leaf margin and, in severe cases, of that part of the lamina between the veins. Traditionally the explanation of this condition is the occurrence of hot days followed by cold nights, hence the name, but in fact all coffee under unfavourable conditions (e.g. immediately after planting) may show the symptoms. "Crinkle Leaf" symptoms appear when the leaf is only a few mm. long: the first sign is a black spot on the lamina which normally is sealed off by a cork layer. When the leaf expands the affected tissue cannot grow in conformity with the surrounding cells. Damage can vary between slight crinkling only and loss of most of the lamina. If this occurs the leaf and internode remain very short. The attack is seasonal, but not uniform for a given area. While it is a very common condition in Africa, there is now every reason to believe that it is unknown in Central and South America. Shade controls the disease to a high degree. When coffee is grown without shade the damage caused can be very severe, particularly in West of Rift regions. Following the observations made by Bock (*Kenya Coffee* Oct. 1959 405–406) on the effect of Captan in controlling the disease, several experiments are now in progress based on these findings.

T. M. WORMER,
Plant Physiologist.

ANNUAL REPORT OF THE AGRICULTURAL CHEMIST, COFFEE SERVICES, 1960

Sodium Nutrition Studies

Sodium nutrition studies in the field have continued. This follows from an earlier finding, where it was noted that, in the absence of a Napier grass mulch, sodium nitrate fertilizer was significantly more efficient than either ammonium sulphate or ammonium sulphate nitrate in increasing coffee yields (ref. Coffee Research Station Annual Report 1959/60, page 62). There was a possibility that uptake of sodium by the coffee tree had some connection with yield increases.

Leaf samples were collected from bearing primaries at monthly intervals during 1960, from plots receiving 46 lb. nitrogen per acre per annum as sodium nitrate (N/S) and as ammonium sulphate nitrate (A.S.N.), in the Mulch and Soil Regeneration Trial. Control and mulched plots (all interrow mulch applied in March) were also sampled. The samples included 1st pair of fully open leaves and 2nd bearing node leaf pairs.

The mean analysis values for leaf samples taken from January to August 1960 are given below.

Per cent of Sodium in the Leaf Dry Matter

	1st fully open	2nd bearing node
Control (1)	0·046	0·053
Sodium nitrate (N/S)	0·056	0·078
Ammonium sulphate nitrate (A.S.N.). . ..	0·050	0·056
Mulch	0·050	0·045
Mulch + N/S	0·062	0·070
Mulch + A.S.N.	0·043	0·055

Following the use of sodium nitrate fertilizer an increased uptake of sodium by the coffee tree is indicated in both the young and older leaves.

In addition to field work some micro-pot test work with sodium and potassium has been carried out, to study the relative value of sodium and potassium in coffee nutrition.

All the solutions used included Hewitt Culture Working Solutions (E. H. Hewitt: *Tech. Comm.* 22, Commonwealth Bureau of Horticulture and Plantation Crops, E. Malling, 1952, p. 140) in which potassium and sodium nitrates were excluded.

The solutions used for treatments were:

(*a*) −Na −K (Control) : Na No3 and KNo3 not added

(*b*) −Na +K : 50 ml. of working solution containing 2·02 gm. KNo3 in 10 litres added weekly to 400 gm. soil for 9 months

(*c*) +Na −K : 50 ml. of working solution containing 3·40 gm. Na No3 in 10 litres added weekly to 400 gm. soil for 9 months

(*d*) +K +Na : Combination of (*b* + *c*)

Some results of this work are given below. The weights, given in grams, are the mean dry weights of the whole plant. The plants were 12 months old.

Treatments		Control	+K	+Na	+Na +K
	Weight (grams)	2·47	2·62	2·99	3·31
Per cent of element in Leaf dry matter	% Na	0·087	0·088	0·135	0·132
	% K	3·12	3·22	3·24	3·49
	% Ca	1·27	1·14	1·15	1·13
	% Mg	0·34	0·39	0·40	0·39

Sodium and potassium (both as nitrates) alone or combined resulted in an increased dry weight of seedlings over the control, sodium being more effective than potassium. Higher levels of sodium in the leaves resulted from sodium nitrate treatments.

Influence of a Napier Grass Mulch on Comparative Coffee Leaf Analysis

Samples of leaves were taken at monthly intervals in 1960, from bearing primaries in the Mulch and Soil Regeneration Trial. Both young leaves (1st pair) and old leaves (2nd node) were sampled.

The mean analysis values for January to August 1960 samples are given below as per cent of element in leaf dry matter.

Mean Leaf Analysis Values for Sodium, Potassium, Calcium and Magnesium (Per cent Element in Leaf Dry Matter)

	Young Leaves				Old Leaves			
	Na	K	Ca	Mg	Na	K	Ca	Mg
No Mulch	0·051	2·23	0·96	0·48	0·062	1·78	1·69	0·49
Mulch (all inter-rows in March)	0·051	2·63	0·94	0·44	0·057	2·08	1·28	0·28

Over the whole sampling period the mulch has increased the mean levels of potassium in both young and old leaves. The leaf calcium and magnesium levels in the old leaves are markedly lowered by a Napier grass mulch. This is in agreement with previous findings*, where it has been noted that a Napier grass mulch significantly increases levels of potassium and decreases leaf magnesium to a point where magnesium deficiency symptoms appear in the mature leaves.

Influence of a Napier Grass Mulch on Comparative Ripe Coffee Cherry Analysis

A short-term experiment was started in May 1959, in an attempt to study the influence of Napier Grass mulch on comparative ripe coffee cherry analysis.

Samples of coffee cherries were taken at weekly intervals over a period of one month, from late May to late June 1959. Comparative samples were taken from mulched (all inter-row mulch in March) and unmulched plots in the Mulch and Soil Regeneration Trial.

The mean analysis values over the whole sampling period are summarized in the table below.

*Ref. Coffee Research Station Annual Report 1959/60.

PER CENT OF ELEMENT IN LEAF DRY MATTER

	N	P	K	Ca	Mg
No Mulch	1·317	0·1248	2·39	0·27	0·20
Napier Grass Mulch (all inter-row mulch)	1·264	0·1463	2·36	0·22	0·18

Over the whole sampling period it is noted that mulch has increased the mean levels of phosphorus and decreased the mean levels of calcium, magnesium and nitrogen. The mean potassium levels (in contrast to leaves) have not been increased by Napier Grass mulch.

THE INFLUENCE OF NITROGEN FERTILIZER ON LEAF NITROGEN IN THE PRESENCE AND ABSENCE OF MULCH

The Nitrogen and Mulch trial* (40 recorded trees) was modified in 1959 to compare the effects upon yields and leaf nitrogen values of various levels of ammonium sulphate nitrate fertilizer applied at different times, in the presence or absence of Napier Grass mulch (mulch was applied around each tree).

In the previous years leaf samples have been collected from this trial and analysed for total nitrogen content. In this respect differences between treatments have been negligible.

In 1960 leaf samples were collected from bearing primaries at monthly intervals and analysed for total nitrogen content. The samples included young leaf samples (1st fully open) and older leaf samples (2nd bearing node). The samples were taken from plots receiving the highest rate of A.S.N. (708 lb. per acre per annum).

The mean analysis values over the whole sampling period are given below.

PER CENT OF NITROGEN IN THE LEAF DRY MATTER

Treatments	Control	+ Mulch	A.S.N.	A.S.N. + Mulch
% N (young leaf)	2·170	2·125	2·200	2·204
% N (older leaf)	1·514	1·531	1·624	1·589

From these results it would appear that the higher rate of ammonium sulphate nitrate (A.S.N.) fertilizer has resulted in higher nitrogen values in both young and older leaves.

IRON CHELATE TRIAL

The fourth year's results were also the second crop from a new multiple-stem pruning cycle.

The yields for four years from this trial have failed to obtain statistically significant differences. The yields for the 1960/1961 season were heavy, as was expected, but the treatments did not exert any effect on the yields.

Leaf analysis values (p.p.m. Fe) for 1959 are now available. They have not shown any difference in Iron levels among the treatments.

P. GACOKA,
Laboratory Technologist (*Agricultural Chemistry*).

*Ref. Coffee Research Station Annual Report 1958/59, page 34.

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N.B.—The report of the Coffee Berry Disease Unit is to be found in Volume I.

GRASSLAND RESEARCH—ANNUAL REPORT FOR 1960

Section I—Review of the Year

At Kitale, in the work on improving Rhodes grass varieties, good progress in understanding the behaviour of this species has been made as a result of chromosome counts of different varieties, and also by means of studies on its method of pollination, and studies on the variability shown by the progeny of selected and tested individual plants. In preliminary grazing trials, Nandi Setaria showed itself to be better than the other varieties tested.

In Rhodes grass variety trials, the Chepararia and Mbarara varieties have given the best yields of leaf material so far. The animal agronomy work has shown the need to use high-yielding milk cows for evaluating pastures, so that the amount of milk obtained from the pasture is not limited by the low milking capacity of the cows used in this type of experiment.

In the fertilizer investigations, further responses have been obtained on the Kitale basement complex soils, to the application of sulphur, potassium and magnesium.

Seed production of the main grasses and legumes is progressing well, and yields per acre have improved with the use of suitable fertilizer treatment, the best being 325 lb. an acre from Slender Guinea grass.

In the Chemistry Laboratory substantial progress has been made in studies on the digestibility and nutritive value of ruminant and pig feeds. It is now possible to predict the nutritive values of these feeds from knowledge of the amount of crude protein which they contain in their dry matter.

At Marigat, work on the reseeding of denuded areas shows that apart from favourable rainfall and the use of suitable species such as *Eragrostis curvula*, *E. superba*, and *Cenchrus ciliaris*, enforced protection from grazing is essential to ensure success.

At the Katumani Experimental Station the dry conditions have shown that Rhodes grass may not be sufficiently drought resistant for use in the district. Work on arable silage crops is being continued, and maize and bulrush millet have done well to date in this connexion. In grass-burning experiments there are indications that at least three-quarter ton of dry grass per acre is needed to obtain a sufficiently fierce burn to affect the susceptible bush species to an appreciable extent. Goats have also assisted in the control of regenerating bush.

At Molo a sward of subterranean clover has been successfully regenerated as a result of cultivation and the application of superphosphate. This seems to be the most productive clover in the high country, and if its regeneration can be assured each year, it may well have a promising future.

Section II—Grassland Research Station, Kitale

(1) Weather and Rainfall

The monthly rainfall, and the number of rainy days in each month, are shown below together with those of last year.

Month	1960		1959		1951–1960
	Inches of rainfall	No. of wet days	Inches of rainfall	No. of wet days	Ten-year means (inches)
January ..	0·74	6	0·50	5	1·027
February ..	1·11	8	3·08	8	1·496
March ..	8·22	19	2·21	9	3·356
April ..	3·09	17	4·80	22	5·325
May ..	3·47	19	5·10	19	5·858
June ..	2·66	15	3·43	17	4·544
July ..	5·86	23	3·71	11	4·322
August ..	7·67	20	3·99	18	6·163
September ..	5·31	17	3·84	19	3·669
October ..	1·52	15	4·88	17	3·434
November ..	1·02	14	4·41	15	2·042
December ..	1·80	9	0·35	2	1·828
Total ..	42·47	182	40·30	162	43·065

The total for the year was only just below the ten-year mean ,but the distribution in April and May was more erratic than usual, and in June neither the total nor the distribution could be regarded as satisfactory. The rainfall in July and August was much better distributed, but the effective rains finished about a month earlier than in 1959.

(2) Plant Introduction and Preliminary Grazing Trials

In grass breeding studies, it was found that the progeny of individual plants of the Nzoia, Mbarara, Mpwapwa, and Ixopo varieties of Rhodes grass (*Chloris gayana*) showed considerable variation in a number of morphological and agronomic characters and it is now evident that these varieties, and perhaps the species as a whole, are cross-pollinating, xenogamous plants. Chromosome counts show that the Nzoia variety has 20 (2n) chromosomes while the Mpwapwa and Mbarara varieties have 40 (2n) chromosomes each, and it appears that both the diploid and tetraploid forms are heterozygous and cross-fertilized. The variability of the progeny of all tested individual plants of Mbarara and Mpwapwa varieties was almost as great as the general variability in these varieties.

One hundred and three new introductions from Kenya and elsewhere were planted in small nursery plots for preliminary evaluation. Good results were obtained from the following: two varieties of Guinea grass (*Panicum maximum*) from Nakuru and Florida, both of a rather small but very leafy type; two varieties of Rhodes grass (*Chloris gayana*), one from Marsabit and one from Sigor in Kenya; a leafy variety of *Setaria sphacelata* from Marsabit, and a variety of Coloured Guinea grass (*Panicum coloratum*) from Kimberley in South Africa.

In a preliminary grazing trial, the Nandi, Meru and Kazungulu varieties of *Setaria sphacelata* and *Setaria trinervia* were compared with and without Kenya white clover (*Trifolium semipilosum*). The Nandi Setaria was generally superior to the others, of which *Setaria trinervia* was the poorest, being the least productive and least palatable. Meru Setaria had a better, more spreading habit than the Nandi variety, but it was less drought-resistant and slightly less palatable. The Kazungulu Setaria was good in the first two years, but it did not withstand periods of drought sufficiently well, and was the least persistent. Nandi Setaria and *Setaria trinervia* were able to form a well-balanced sward with clover, while Meru Setaria, with its somewhat spreading habit, suppressed the clover to a very considerable extent. The plots of Nandi Setaria and *Setaria trinervia* mixed with clover produced markedly more vigourous grass than the plots of grass alone.

(3) Ley Species and Grassland Management

Work has continued on species for general purpose and dry season leys, the use of legumes, pasture management, and the growing of arable (annual) forage crops. The following is a brief description of some of the main results:—

For general purpose leys the Rhodes grass varieties, Chepararia, Mbarara, Masaba (a selection from the Endebess variety), Mpwapwa, Nzoia, and Alego are being compared by means of a clipping trial. The first two seasons' results are given below. The figures represent the yield of leaf material after extraction of stems, in cwt. per acre of dry matter, being the mean of two seasons: Chepararia 60, Mbarara 60, Masaba 56, Rongai 53, Mpwapwa 51, Nzoia 50, and Alego 42.

So far, Chepararia and Mbarara have outyielded Rongai, Mpwapwa, Nzoia and Alego, but have not been significantly better than Masaba. Although there was no significant difference in yield of leaf between Masaba, Mpwapwa and Rongai, the two latter varieties produced a higher proportion of stem and were therefore probably slightly inferior.

These Rhodes grasses are also being compared in a grazing trial, now in its third year, in which each variety was sown separately with Kenya white clover (*Trifolium semipilosum*), Louisiana white clover (*T. repens*), and Ladino clover (*T. repens*). After making a strong start the Ladino and Louisiana clovers have largely died out during the dry weather, but Kenya white has persisted vigorously and shows signs of becoming dominant in some mixtures.

In addition to work on species for the longer term leys of three years or more, attention is also being given to species for short-term leys of 1–3 years' duration, in which certain of the less persistent plants might also prove useful.

A large number of plants were established by undersowing in maize and, as a result of observations, the following are recommended for further trial for this purpose:—

Melinis minutiflora, *Chloris gayana*, *Beckeropsis uniseta*, *Bromus unioloides*, and among legumes and herbs: *Trifolium repens* (Louisiana white clover), *Trifolium pratense* (Chilean red clover), and Chicory.

The use of drought-resistant grasses and legumes for extending the grazing season has often been suggested, and work on this aspect has been in progress for a number of years at Kitale. However, this idea will only be acceptable if the production of herbage in this way does not entail too much loss in yield and quality. One trial has been established to compare the dry matter and crude protein yield from pastures managed for dry season use, with the yields from similar pastures in which the bulk of the herbage is used during the rains. The species are Gold Coast elephant grass, Sigor guinea grass, molasses grass, and giant Setaria. During the first year there was no significant difference in the effect of the two management treatments on the mean yield of dry matter, but the dry season treatment reduced the yield of crude protein by about one-third. It seems therefore that the conservation of standing herbage can result in a substantial loss of nutrients, and future work on the management of "dry season" pastures will be directed to reducing this loss.

As a sequel to earlier work on the management of grass-legume mixtures, a further trial is in progress to observe the effects of sheep and cattle grazing on the grass-clover balance of Rhodes grass, Nandi Setaria, and molasses grass leys containing Kenya white clover. The proportion of clover in the molasses grass mixture has been strikingly increased by cattle grazing, otherwise there have been no obvious effects on the proportions of grass to clover which could be attributed to the different types of animals. Furthermore, the molasses grass effect is probably due to the trampling out of much of this grass by the cattle, rather than to their grazing action. However, distinct differences have been seen in the general growth of the pastures, the sheep tending to bring about a closer and more even sward than the cattle. It is therefore thought that, as in other countries, sheep might be used with good effect for following after cattle to tidy up and give more efficient utilization of the pasture.

Several arable (or annual) forage crops, namely maize, oats, velvet sorghum, Columbus grass, perennial Kavirondo sorghum, and Sudan grass, have been compared for the production of silage material from their first flush of growth, and also for their seasonal yield of dry matter and crude protein.

Sudan grass (91 cwt./acre of dry matter), perennial Kavirondo sorghum (98 cwt.) and velvet sorghum (104 cwt.) gave significantly higher yields D.M. than either oats (60 cwt.) or maize (60 cwt.) during a complete season. Since the completion of the first year's results the Columbus grass has persisted quite strongly and it may therefore have possibilities for use in leys of more than one season's duration under these conditions.

(4) Fertilizer Experiments

Two field experiments are in progress with lucerne to determine the calcium, sulphur, potassium and magnesium requirements of the crop. These two experiments have been running for two years, and the dry matter yields for 1960 are as follows: increase of phosphate alone treatment over control, 1,900 lb. D.M. per acre, and increase of phosphate plus sulphur (32 lb. S per acre) treatment over phosphate alone, 1,000 lb. D.M. per acre, significant at 0·1 per cent level. In another lucerne experiment, the addition of magnesium together with phosphate increased the yield by 1,200 lb. D.M. per acre compared with phosphate alone, and was significant at the 0·1 per cent level.

In a further lucerne experiment, the addition of potassium to an application of Mg, S, and P gave an increase of 850 lb. D.M. per acre, significant at the 1 per cent level.

In a Rhodes grass experiment, the application of 100 lb. of potassium plus 20 lb. of magnesium, contained in fertilizers, gave a 25 per cent increase in yield, significant at 0·1 per cent. A response by grass alone to the application of sulphur has been obtained for the first time this season, which will be further investigated. These results, together with other trends which have been observed, indicate the need to maintain a proper balance between the major plant nutrients, and also that other elements may be needed by plants in addition to nitrogen and phosphate.

(5) Comparison of Pastures by Animal Production

This year has seen the start of the first milk production trial, described briefly below.

The experiment on the production of milk from pasture, with two stocking rates, using twin cattle, which was started in April 1960 continues, but lactations are not yet complete in most cases. The effects of stocking rate on production are similar in trend to those shown by Hancock in New Zealand, i.e. the more intensive rate coincides with a lower yield per head but a higher yield per unit area, and vice versa.

In treatment 1, which permits of reasonably ample D.M.I. from the grass, there is a higher proportion of pregnancies in the permitted period, with 1·57 services per conception, than there is in the co-twins on treatment 2, which is 33 per cent less in area. The latter twins required 2·0 services per conception, with a smaller proportion of pregnancies.

However, in lactation yield the biggest differences are between pairs, not between treatments. It is quite clear that under the conditions of the experiment the pastures (4th year Setaria and 2nd year molasses grass without fertilizers) have been capable of providing for a lactation yield of 500 gallons F.C.M. (200 lb. B.F.) in a season of erratic rainfall. Yet the lowest pair of completed lactations is less than 60 gallons F.C.M., which indicates the overriding influence of the genetic potential of th animals. The inference is that the basic need for improving the lactation yields from grass where they are below 500 gallons with spring calving, lies very much more in improving the stock than ley pastures, as far as quality is concerned.

There is also no doubt that the carrying capacity of the leys used is less than it should be after the first year. This is well illustrated by results from the species comparison described below.

In a comparison of liveweight gain from Nandi Setaria, Nzoia Rhodes, and molasses grass, using twin cattle, all three species yielded considerably less L.W. gain in this, the third year, than in 1959, in spite of the use of sulphate of ammonia and double superphosphate as a topdressing.

The results in lb. liveweight gain per acre are given below for 1959 and 1960 respectively for each species, together with the percentage decrease in liveweight gain for 1960. Nandi Setaria, 297 and 170 lb. decrease 42 per cent, Rhodes grass 327 and 195 lb., decrease 40 per cent, and molasses grass 327 and 116 lb., decrease 64 per cent. The means for reducing these decreases are being sought in the agronomy and fertilizer investigations described earlier in this report.

In the natural grassland rotation trial, results, using F1 Boran x Red Poll stock have been on a slightly higher level, but similar to those in the previous three years, when the two leading treatments have been either the continuous grazing treatment or the 4-paddock rotation. This year the former was slightly better than the latter. The 3-paddock deferred rotation was again behind the other two this season.

(6) Seed Production

Work on seed production: sixty acres have been under production of Mother seed this year, the principal varieties grown being: Masaba, Mbarara and Mpwapwa Rhodes grasses, Nandi Setaria, Slender and Coloured Guinea, Kitale molasses, Kenya white clover and a promising new seeding variety of *Brachiaria ruziziensis* from the Congo.

The highest yield of the year was from Slender Guinea grass, at 325 lb. seed per acre, and several others produced over 200 lb. an acre, but the overall average was 105 lb. an acre with a total of 6,700 lb. of seed produced.

Under the seed certification scheme, nine farms with a total of approximately 300 acres under seed production have passed the field testing, and government certified pasture seed should in future be available commercially. Almost all seed is at present being produced in the Trans Nzoia, and it is hoped that farmers and seed companies in other districts will be encouraged to take a more active interest in seed production, which can be a very profitable undertaking.

(7) Pasture Research Chemist's Investigations

The apparent digestibility of the non-nitrogenous component of ruminant feeds.—In last year's Annual Report it was mentioned that in our joint studies of the chemical changes that take place in plant composition during growth and maturation Mr. Glover, Plant Physiologist, E.A.A.F.R.O., and Dr. H. W. Dougall found that while plants may differ in their carbohydrate (CHO)/crude protein (CP) ratios during growth, the different ratios all conform to a simple, overall pattern. We showed that there is a relationship between the carbohydrate/crude protein ratio in plant material and the nutritive ratio (NR) of the animal nutritionist, the NR being a similar ratio in terms of digestible nutrients since it is the ratio of the digestible non-protein (DCHO) to digestible crude protein. We suggested that this result implied a relationship between total and digestible carbohydrate as well as between total and digestible crude protein (DCP). This aspect of plant/animal relationships has been examined by us during the present year.

We find that the digestibility of the non-protein component (almost entirely carbohydrate) of ruminant feeds is a function of the level of the crude fibre and crude protein components, and that the effect of increasing crude fibre in the diet is to depress the digestibility of carbohydrate irrespective of the level of the crude protein associated with it. The effect of crude protein on the digestibility of carbohydrate is only well marked when its concentration in the dry matter of the feed falls below some 5 per cent, that is when the feed is below approximate maintenance levels. Increasing the crude protein content of the diet from some 2 to about 5 per cent leads to increased digestibility of carbohydrate but thereafter in the range of some 6–30 per cent crude protein the protein effect is slightly depressing to carbohydrate digestibility and is apparently quite negligible at average crude fibre concentrations to be expected at any given level of crude protein.

The implications of these results are that the variability in digestibility of the non-nitrogenous component of ruminant feeds depends mainly on the respective levels of crude protein and crude fibre in the diet and to a much lesser extent, if at all, on the species of ruminant or class of feed, be it silage, roughage or mixture.

Total digestible nutrients and gross digestible energy in ruminant feeds.—A simple way in which total digestible nutrients (TDN) may be measured is derived from consideration of the definition of the nutritive ratio (NR). The expression

$$NR = \frac{TDN—DCP}{DCP}$$

leads to TDN = DCP (NR + 1), where DCP is, of course, the amount of digestible crude protein contained in the feed. Thus if the digestible crude protein and nutritive ratio are known, or can be estimated by various means, they can be substituted in the above expression to provide estimates of TDN. Fortunately, both DCP and NR can be estimated; thus

DCP = CP (5 + 60 log CP — 0·33 CF) (Glover & French, 1957) where CP and CF respectively represent the amount of crude protein and crude fibre contained in the dry matter of the feed, and

log NR = 2·76 — 1·69 log CP — 0·003 CF (Glover & Duthie, 1958). Both of these equations provide automatic corrections for much of the inverse relationship between crude protein and crude fibre which is encountered in normal feeding stuffs.

Gross digestible energy (GDE) is very closely related to TDN for:—

$$GDE = TDN + 0{\cdot}4\ DCP$$

Glover and Dougall have derived this equation as follows: the relative proportions of gross metabolizable energy in the digestible components of a feed are approximately carbohydrate 1·0; protein 1·4; and fat 2·25 (Morrison, 1957). In the calculation of TDN or NR the digestible fat component already has been multiplied by 2·25 to correct for its higher energy so that TDN — DCP only requires to be multiplied by unity to give the gross energy of the non-protein components in terms of the energy of starch as unity. The remaining component DCP must be multiplied by 1·4 to provide a similar estimate of the energy of the digestible crude protein so that gross digestible energy is

$$(\text{TDN} - \text{DCP})\ 1 + 1{\cdot}4\ \text{DCP}$$

i.e. GDE = TDN + 0·4 DCP.

Reasonable estimates of the average amounts of total digestible nutrients and gross digestible energy as well as the digestible crude protein contained in the dry matter of ruminant feeds can therefore be derived from knowledge of only the crude protein and crude fibre contents of such material as fed. Estimates so derived do not appear to be markedly affected, if at all, by differences in class of feed or species of ruminant, whether cattle, sheep, or goat. Inherent in the relationship between either total digestible nutrients or gross digestible energy and the proximate partial composition of the feed is a suggestion that if a low plane of protein nutrition is prolonged, that is, when the crude protein of the diet lies persistently below some 5 per cent of the dry matter of the feed, there is likely to be a sharp fall in the total digestibility of the feed.

A table of average estimates of digestible crude protein and total digestible nutrients to be expected at different levels of crude protein and crude fibre has been prepared for use in the estimation of the average nutritive value of feeds whose digestibility has not been studied by means of numerous digestibility trials. Thus by use of this table it has been possible to record average nutritive values for well over three hundred Kenya grasses, legumes, cereals and cereal products, etc., and to compute rations for dairy cows and other ruminants according to the system of rationing recommended by Morrison (1957) or Evans (1960) or according to Forbes' (1932) concept of regarding rations as "wholes". It has also been possible to assess the value of Kenya pastures at different stages of growth for milk production.

Milk production from Kenya pastures.—Glover and Dougall find that the available energy (TDN) contained in the dry matter of Kenya pastures at all stages of growth is remarkably constant. Thus in the early stages of growth of such pastures when the available crude protein is present in amounts suitable for very high milk yields the available energy limits their attainment. During later growth, as the amount of crude protein in the pasture becomes increasingly diluted by carbohydrate there is a progressive decrease in the amount of available digestible crude protein and it in turn becomes inadequate to sustain the original level of productivity. At the point of change-over from TDN to DCP as the limiting factor there is a narrow zone of pasture composition from which maximum production can be obtained with minimum waste. The proximate composition of the pasture in this region can be specified simply by the crude protein content of its dry matter. The narrow range of values which define this zone depend on which of the recognized feeding standards are adopted for their estimation. If Morrison's and also Evans' are used, the estimates derived from them suggest that pasture containing some 11–14 per cent crude protein in its dry matter is most efficient for milk production with minimal waste. No closer definition of the zone can be made until the feeding standards in current use are more closely reconciled. Glover and I consider that the reserve of energy stored in the animal at the time of calving is important in compensating for the limiting energy of good pasture which is otherwise suitable for higher milk yields.

Section III—The Grassland Research Station, Molo

The most significant result obtained here during the year has been the regeneration of a field of Bacchus Marsh subterranean clover on a field scale. Varieties of subterranean clover such as Mount Barker and Bacchus Marsh have grown well here in the past, and produced as much as 25 tons per acre of green material on a plot scale, but the difficulty has always been to obtain adequate regeneration of the clover

in the following season. This has been achieved this year by means of an initial high seeding rate of 12 lb. per acre of the Bacchus Marsh clover, and at the start of the second season the application of 1 cwt. of triple superphosphate together with cultivation by means of a heavy disc-harrow. The result of this was a good sward of clover and Westerwolths ryegrass in the second year. These findings will now be followed up further. Other pasture legume species have not so far been as productive as this species at the high altitudes (9,000 ft.), and it seems well adapted to the relatively cool and somewhat acid soil conditions which occur widely in the Molo area.

Section IV—Grassland Research Work at Katumani

At the Katumani Research Station 1960 was a dry year, and the cumulative effect of a long period of poor rainfall became increasingly marked. Although the total for the year was nearly average the distribution was poor. During the April rainy season, rain came on and off for six weeks and then ceased altogether, causing many crops to wilt before they were ready. During the November rainy season the month of November was abnormally dry and crops were retarded.

The monthly rainfall figures are as follows:—

January 0·21, February 0·69, March 4·32, April 5·94, May 1·17, June 0·02, July 0·96, September nil, October 2·53, November 1·06, December 6·44. Total: 23·29 inches.

The dry weather has shown up the relative advantage of annual to perennial fodder crops. The annual fodder crops such as maize or Bulrush millet are more reliable under conditions of low rainfall than perennial fodder grasses such as elephant grass and guinea grass. It appears that the perennial fodders exhaust the sub-soil moisture during the dry season while producing little growth and may be so weakened by drought that they do not recover quickly with the onset of the rains. Annual fodders grow quickly as soon as the rains come and make full use of any sub-soil moisture which may be available.

Of the annual fodder crops tried, maize and Bulrush millet have both given good results, but in seasons of high rainfall the former will outyield the latter. Sudan grass is valuable for the aftermath grazing, but the depletion in sub-soil moisture which results may preclude its use on smallholdings where it would be followed immediately by another crop.

Interplanting of maize for silage (spaced 2′ x 1½′) with the white seeded *Dolichos lablab* (Njahi) can give a substantial increase in the yield of crude protein per acre with a relatively smaller decrease in total dry matter yield.

Soya beans have been found insufficiently drought-resistant and Velvet beans too slow maturing for inclusion in silage mixtures.

The dry conditions have emphasized the problem of weed competition when establishing grasses such as *Cenchrus ciliaris* by broadcasting seed.

Planting splits of *Cynodon dactylon*, which can be weeded, requires more labour initially, but provided the land is fertile, a good sward will be obtained much more quickly.

Burning experiments have shown up big differences in the reaction to fire of different bush species. Where there is a high proportion of fire, susceptible species such as *Wedelia* sp., *Crotolaria saxatalis* or *Acalypha fruticosa*, land can be quickly opened up by two or three burns repeated at intervals of one or two years. Where, however, there is a high proportion of fire-resistant species such as *Acacia brevispica* or *Maytenus putterlickiodes* fire is much less effective.

At least three-quarters of a ton of dry grass is needed in order to get a good fire, and if the rainfall is average and the sward not overgrazed resting during the April rains will produce this amount. Under conditions of low rainfall or overgrazing two seasons' rest may be required.

Goats not only utilize forage in the form of leaves and twigs which would otherwise be wasted, but in so doing help to prevent regenerating bush from getting too tall and out of reach of fire.

Burning has been shown to reduce basal cover and care is needed when burning steep land to minimize erosion.

Section V—The Grassland Research Station, Marigat

Whilst experimental work on the drier natural grasslands of the Rift Valley Province has continued throughout 1960, both ley grasses suitable for marginal areas and irrigated pastures (at Marigat) are now also under study. The annual rainfall over much of the area served has been exceptionally low (the total of 15 in. at Marigat being 10 in. below average); and this naturally has had a marked effect upon experiments in progress.

One occasional survey was undertaken and reported upon during the year:

"The Grazing Areas of the Lower Uaso Nyiro Basin". Illustrated Report plus 2 maps. July 1960.

Experimental Work

(*a*) *Natural Grassland*

(1) *Grassland Rehabilitation.*—In keeping with the spread of controlled grazing schemes within the African areas of the R.V.P., the field study of the effects of grazing rotation on vegetation composition has been extended to cover a variety of schemes, using the approach outlined in the 1959 Report (expt. 13/A/1).

Further information has been obtained on reseeding as a possible aid to the rehabilitation of denuded areas. Concisely, success in reseeding has been found to be as dependent on enforced grazing control and adequate soil cultivations as it is on favourable rainfall and the choice of adapted species. Results (expt. 13/A/2) show that grazing control as often practised (cf. Baringo) is insufficiently maintained to make reseeding within the framework of a normal rotation a practical proposition: thus, where the rest period allegedly offered by the rotation was enforced by fencing, a plant population resulted which was eleven times that obtained without fencing. Regularly, the initial plant population has been found to be correlated with the degree of seed-bed cultivation, though the need for large terraces as a precaution against flood wash has been confirmed nevertheless (expts. 13/A/2, 13/B/38).

Changes in grass composition inevitably follow establishment, but the regression recorded near Marigat following two successive poor seasons is unusual, in that a previously well-developed perennial grass cover has reverted to virtually bare ground (expt. 13/B/38). By the same token, techniques and materials which gave outstanding results in 1958 were a complete failure in 1960 (rainfall 31 in. and 15 in. respectively). In higher rainfall areas (35 in. average) a perennial cover readily persists, but it has been found that the species which contributes most to the establishment of the initial cover, *Chloris gayana* (Rongai), cannot maintain itself, and cannot therefore be recommended for normal reseeding purposes (expt. 13/B/16). In this connexion, the rapid establishment of a cover by short-lived perennials has nowhere been found to assist in the spread of the more persistent species sown, as neither has the density of the original cover affected the ease of establishment of seeded grasses. Under these conditions, reliance is better placed on adapted varieties of *Eragrostis superba* and *Cenchrus ciliaris*.

Many of the dry-area grasses under nursery selection at Marigat (expt. 13/C/44) died during 1960. Credit for relative ease of survival is accorded to:—

Cenchrus setigerus, M.5714; *C. ciliaris*, M.5724, M.586 and M.5911; and *Eragrostis* sp., M. 5713.

(2) *Bush Control.*—In dealing with dense *Tarchonanthus*/*Acacia* stands, emphasis is placed on fire as the major agency of control. Where the canopy is too dense (and the grass cover too poor) to permit the starting of a burning cycle, suitable conditions

can be obtained by the use of the Holt IX bush breaker, complemented by reseeding (expt. 13/B/39/2). At this particular site, the overall bush population now stands at 1,080 plants per acre, following a 44 per cent increase since 1959. A greater or lesser increase has resulted from all of the various clearing, reseeding and burning combinations applied, and in each case this is referable to four bush species, of which *Acacia brevispica* (as the most pernicious) is particularly important.

It has been found that reseeding is essential both to facilitate burning and to control the increase in seedling trees which invariably follows clearing with a Holt machine. Thus, considering the area where clearing was performed in 1958 (treat. H.58), the percentage increase of *A. brevispica* has been 61 per cent in the absence of reseeding, as opposed to 28 per cent where reseeding has accompanied clearing. With the addition of burning (March, 1960), the increases have been reduced to 54 per cent and 14 per cent respectively. These figures should be compared with the 76 per cent increase obtained under the complete control treatment. In addition to the reseeding aspect, it was found that an efficient fire was obtained only where two seasons' rest had elapsed following clearing. Satisfactory fires were not obtained where cleaning had been performed in 1959 (treats. H.58/9 and H.59).

Additional work with the Holt IXa indicates that the season of application has little effect on the response of the bush to clearing. This is equally true whether the bush type be *Acacia/Tarchonanthus* thicket in S. Baringo (expt. 13/B/39/3) or *Disperma* dominated grassland in Samburu (expt. 35/4).

Where conditions permit burning without prior clearing, the advantage of starting the cycle with a burn in two successive seasons has been demonstrated (expt. 13/B/18). Double clearing with the Holt has had no such effect. Both *Tarchonanthus* and *A. brevispica* (the dominants at this S. Baringo site) are fire-resistant, but the double burn has encouraged a swing of the balance towards grass to an extent that the bush is now regenerating under severe competition. Here, selective hand lopping and the use of goats complement the fire treatments: the former has continued to facilitate uniform burning (cf. 1959 Report) and also the access of the goats to the regeneration. Local goats, whilst giving to bush less than 30 per cent of their attention, adequately defoliated, in time, all species within browsing height. In contrast, goats from N. Baringo showed completely different preferences, and disliked *Tarchonanthus* in particular. Browsing has not yet had any permanent effect on the bush, and rapid regeneration occurs once the goats are removed.

In all trials, burning at the end of the dry season has improved the grass cover, and has not as yet significantly affected the contribution made by stoloniferous species such as *Chloris gayana* and *Cynodon dactylon.*

(*b*) *Dry-land Leys*

In comparison with twelve other grasses at Chemogoch, S. Baringo (expt. 13/C/46), *Chloris gayana* (Rongai) has continued to show itself to be the superior. In view of the adverse season, particular merit may be attached also to the relative success of *Melinis minutiflora* (M.5810) and *Chloris gayana* (Endebess). Amongst further material planted during 1960, *Chloris gayana* (Chepararia) and *M. minutiflora* (M.602) have established well, and the latter has maintained its productivity well into the dry season.

A variety of pasture legumes has been planted at Chemogoch, but with little success. In view of the poor season, this is not considered to be conclusive.

(*c*) *Irrigated Pastures* (expt. 13/C/45)

Under irrigation at Marigat, the best-adapted grasses grow at a rate in excess of 1 in. per day, necessitating grazing every 15–18 days. Into this category fall *Panicum coloratum, P. maximum* var. *trichoglume* and *Chloris gayana* (Mpwapwa and Chepararia). When subject to such competition, otherwise productive pasture legumes are only able to survive for longer than six months when in association with a tufted grass. *Chloris gayana* was found to swamp all legumes included with it, and with the *Panicum* spp. only *Clitoria ternatea* (M.5735/6) contributed more than 15 per cent to the total herbage produced. The legumes under trial include species of *Desmodium, Dolichos, Glycine* and *Medicago,* in addition to *Clitoria.*

Slower-growing grasses, requiring grazing every 3–4 weeks, allow their companion legumes a better chance of survival, but the increased legume growth has not compensated for the lower productivity of the grass itself. The gap is most nearly bridged by *Melinis minutiflora* (M.602) growing in association with *Clitoria ternatea*, where the contribution of the legume exceeds 50 per cent of the total herbage. A greater bulk of fresh grass is produced by *Setaria splendida*, but at the chosen grazing stage the dry matter of this species is only 14 per cent, as compared with 24 per cent for *Melinis*.

Section VI—Publications

A. V. Bogdan.—The breeding behaviour of molasses grass in Kenya. *E.A. agric. for. J.* 26, 49–50, 1960.

A. V. Bogdan.—A molasses grass variety trial. *E.A. agric. for. J.* 26, 132–133, 1960.

A. V. Bogdan.—Climate and grass breeding in Kenya. Proceedings of the 8th International Grassland Congress, 1960.

E. D. Bumpus and R. G. Poultney.—The problem of nitrogen fixation by legumes in Kenya in relation to soil nutrient status. Proceedings of the 8th International Grassland Congress, 1960.

H. W. Dougall.—Average nutritive values of Kenya feeding stuffs for ruminants. *E.A. agric. for. J.* 26, 1960.

H. W. Dougall. –Average nutritive values of Kenya feeding stuffs for pigs. *E.A. agric. for. J.* (in the press).

H. W. Dougall and A. V. Bogdan.—The chemical composition of the grasses of Kenya II. *E.A. agric. for. J.* 25, 241–244, 1960.

H. W. Dougall (with J. Glover and D. W. Duthie).—A table of estimates of nutritive values of ruminant feeds. *E.A. agric. for. J.* 26, 1960.

H. W. Dougall (with J. Glover).—A table of estimates of nutritive values for pig feeds. *E.A. agric. for. J.* (in the press).

H. W. Dougall (with J. Glover).—The apparent digestibility of the non-nitrogenous component of ruminant feeds. *J. agric. Sci.* (in the press).

H. W. Dougall (with J. Glover).—Estimation of the average total digestible nutrients in pig feeds. *J. agric. Sci.* (in the press).

H. W. Dougall (with J. Glover).—Milk production from pasture. *J. agric. Sci.* (in the press).

H. W. Dougall (with J. Glover and D. W. Duthie).—The total digestible nutrients and gross digestible energy of ruminant feeds. *J. agric. Sci.* (in the press).

E. D. BUMPUS,
Senior Pasture Research Officer

ANNUAL REPORT OF THE SENIOR HORTICULTURAL OFFICER, 1960

Review of the Year

The transformation of the Horticultural Produce Committee into a statutory board has been recommended in the report of the McGillivray Committee, and it is hoped that this will take place during 1961. The Committee met about once monthly during the year and carried out investigations into many aspects of the horticultural industry and made recommendations accordingly.

The Thurgood Report which made recommendations on the organization of horticultural marketing in Kenya was considered by the H.P.C., and several of the recommendations have since been implemented, at least in part. Plans are now well advanced for the new Nairobi wholesale market which is to replace the existing Mincing Lane market which the City has long outgrown. A weekly broadcast news service of horticultural wholesale prices has been started. Rules laying down standards for horticultural produce for export are now in force, and their efficient operation has been made possible by the engagement of a Horticultural Produce Inspector. Exporters have co-operated well, and the Inspection Service has worked smoothly since its inception.

Pineapples

In 1960, the intake of fruit processed by Kenya Canners Ltd., and Kenya Orchards Ltd., remained too low to be economic (11,236 tons). The production of pineapples available for processing must be raised to at least 16,000 tons per annum, to enable both canneries to operate economically. With minor modifications to their plant, the two canneries could handle up to 33,000 tons per year.

The Kenya Government has now agreed to provide considerable backing for the industry, and as a result, a vigorous campaign has been launched by the Agricultural Dept., to expand pineapple production for canning to a total of at least 23,000 tons by 1962.

In connexion with the campaign to increase production a survey of the pineapple acreages in both the European and African areas has been started. The object of the survey is to obtain reliable information on the age and condition of the current acreages so that the new plantings can be planned and directed. Increased production must come from increased plantings and the application of fertilizer. ALDEV loans are being made available to African farmers to finance this project.

From preliminary findings in the pineapple survey, the standard planting distances are not being employed in the African areas, and this has the effect of reducing by half the potential yields from those acreages. It is also clear that no fertilizer is being used on pineapples and much planning, persuasion and publicity with practical demonstrations will be required to convince the African growers of its value.

Onions

In spite of evasion of onion imports control the Nairobi wholesale price did not fall below 25 cents/lb. during the year for Bombay Red onions of reasonable quality. This, combined with the Department's campaign for increased production, has had a stimulating effect on local growers, and there is no doubt that production has improved both in quantity and quality. Kenya is however still a long way from being self-supporting in onions.

Tomatoes

There was no production of tomatoes for canning in 1960, and this resulted in tomatoes being in glut supply on the local market at certain times, particularly from Machakos district. It is hoped that there will be a resumption of tomato canning in 1961.

Strawberries

The increase in production resulting from improved cultural methods has caused the price of relatively high grade strawberries to fall on the local market. Many up-country growers have experienced difficulty in getting their strawberries to Nairobi by rail in suitable condition for export or even for the local market. The quantities involved are not large enough to justify special freight facilities on the Railway. The only answer would seem to be light road transport operated co-operatively by the growers.

Citrus

Investigation of the qualities of Kenya lemon juice in co-operation with Messrs. Schweppes has now been concluded, and a report has been included under "Record of Investigations" below. Trees of the right varieties for lemon juice production, are being produced at Thika. The lemon juice export scheme is however held up because so far it has not been possible to raise any sort of guarantee of a processing plant being in operation by the time trees start to come into bearing. (S.H.O.)

Record of Investigations

Tree Crops

Deciduous Fruit Tree Crops

The mean yields of the best deciduous fruit tree crops at Molo for the 1959/60 season are shown in Table 1.

Table 1

Kind	Variety	Rootstock	Yield per tree lb.	
Apple	Springdale	Crab	71	(46)
	Abundance	„	44	(56)
	Bramley's Seedling	„	79	(72)
	Winter Banana	M.XIII	54	(26)
Pear	Keiffer	Own Roots	86	(122)
Peach	Alexander Jewel	Peach	52	(135)
	Angel	„	49	(89)
	Waldo	„	33	(44)
Plum	Settler	Own Roots	320	(256)
	Jardine's Early	Peach	248	(18)
	Tazagine	Own Roots	212	(122)
	Wilson	Mariana	170	(175)

The 1958/59 season's yields are shown in parenthesis. A rust disease of plums which causes a serious spotting on the skin of the fruit has been reported from many districts and was quite serious at Molo during the 1959/60 season causing a loss of as much as eighty per cent of the fruit on some of the early varieties (3) and (4).

Sub-Tropical Tree Fruits

At the fruit sub-station Kitale, the yields from the heaviest bearing trees are shown in Table 2.

Table 2—Mean Yield for Sub-Tropical Fruit Trees 1960 Crops

Kind	Variety	Yield per tree in Lbs.	
		Irrigated	Unirrigated
Orange	Washington Navel	204 (63)	131 (67)
	Valencia Late..	261 (147)	163 (81)
	Renmark Navel	210 (76)	96 (30)
	Parson Brown	243 (194)	84 (68)
	Lue Gim Gong	160 (59)	133 (118)
	Empress Mandarin	290 (83)	— —
Grapefruit ..	Triumph Seeded	236 (160)	144 (152)
	Triumph Seedless	167 (69)	128 (149)
	Marsh Seedless	378 (192)	258 (224)
Tangerine ..	Beauty of Glen Retreat ..	170 (30)	74 (20)
Lemon	Eureka	194 (225)	73 (124)
	Lisbon..	198 (242)	125 (187)
	Villa Franca	273 (279)	100 (169)
	Meyer	220 (157)	125 (157)
Lime	Mexican	133 (144)	78 (73)
	Tahiti	156 (169)	130 (91)
Avocado	Puebla	178 (24)	102 (65)
	Fuerte	478 (127)	269 (134)
	Mayapan	278 (228)	218 (305)
	Totals	4,427 (2,668)	2,431 (2,214)

The 1959 yields are shown in parenthesis. Irrigation is having a very marked influence on yields, and the yields for oranges and grapefruit have shown a considerable increase over the previous years. There are no unirrigated Empress Mandarin trees. Grapefruit yields are promising but apart from giving some indication of the yield potential the quality of the fruit is poor. The Triumph varieties are too small for commercial use on the fresh market, and the Marsh Seedless are too thick in the rind. (3) and (4).

Citrus Keeping Trial

A trial was started during December 1959 to investigate the use of certain fungicides to control the growth of green mould, *Penicillium digitatum* and blue mould, *Penicillium italicum* which are troublesome among citrus, in store. The fruits were stored in an underground cellar, at Molo, at a temperature between 52° F. and 56° F. The treatments and results were as follows:—

Fungicide treatments	Per cent fruit surviving after 4 weeks	Per cent fruit surviving after 8 weeks
1. Sofonate 1½ ozs. per gallon of water ..	88·0	70·0
2. Murphy's Orthocide 50 per cent Captan ½ oz. per gallon of water	76·6	60·0
3. Blitox 1¼ ozs. per gallon of water	73·0	66·6
4. Nil treatment	70·0	40·0

Citrus Juice Industry

The series of lemon juice samples sent to Messrs. Schweppes London laboratory for commercial assessment has now been completed. Messrs. Schweppes final report on the samples is as follows:—

"Regular samples were received between March 1959 and October 1960 from the two main areas Naivasha and Jacaranda with a few from Machakos (higher altitude plantings). On the whole the latter have been less promising than the two main areas.

The Jacaranda samples were from the varieties Lisbon and Villa Franca and samples from Villa Franca fruit were less satisfactory than those from Lisbon fruit and were more often found to have a bitter flavour. The Naivasha samples were from a mixture of Lisbon, Eureka and Villa Franca fruit.

The citric acid content was at a satisfactory level in nearly all samples with a slightly higher average figure for the Naivasha samples than for the Jacaranda samples, 7·08 against 6·67 per cent w/v as crystalline citric acid.

There was an indication that the citric acid content increased during the September to February period.

The examination of samples over the whole period indicates that juice of satisfactory commercial quality can be produced from the fruit available.

The most important criticism is the presence of a slight bitterness in some of the samples. This is always undesirable in lemon juice and especially if intended for concentration. The method of expression is of great importance and the flavour can be influenced greatly by the amount of pressure applied in reaming the juice. A clean, fresh, characteristic lemon flavour is required, free from bitterness and without excessive peel oil.

All samples subsequent to No. 37 have been laboratory pasteurized and all were of satisfactory appearance and colour."

Pineapples

Fertilizer on Replant Land

In May 1957 a trial was laid down at Karamaini Estate, Thika on a pineapple replant area of Kikuyu red loam to compare sulphate of ammonia and urea as a source of nitrogen. Both materials were compared using foliar sprays and solid soil applications, each at two rates of application.

The trial was planted on 3–5–57 at the standard two-row bed spacing of 1 ft. x 2 ft. x 3 ft., accommodating 17,000 plants per acre.

The design was randomized block with four replicates, each plot containing 30 plants.

The solid soil applications were applied in five equal dressings the first application being made on 3–6–57 when the plants were established, and the final application on 19–5–58 when the plants were just over one year old.

Five foliar spray treatments were applied at the same time as the ground applications. By September 1958 the ground applications of nitrogen had resulted in vigorous and healthy growth of the plants, whereas there was little visual effect from the spray treatments compared to the untreated controls. Since the sprays had given such poor responses further spray applications were made to bring the total amount of nitrogen applied in line with the solid soil treatments, the final application being made on 21–10–58. In March 1958 iron deficiency symptoms became evident and the whole area was sprayed six times at weekly intervals with 0·1 per cent Ferrous Sulphate.

Harvesting of the first crop commenced in February 1959 and by the end of May 1960 91·6 per cent of the plants in the trial had fruited. The results are given in Table 3. As to be expected the heavy applications of nitrogen have had beneficial effects on the yields but the most interesting and significant results ($P=0·01$) have been the effect

of time on cropping behaviour, and at the same time the effect of deep versus normal planting on speed of establishment.

Trials have been started on closer planting by comparing 14,000, 17,000, 19,000 and 23,000 plants to the acre, the aim being to increase the yield per acre without a proportionate increase in cost. Similar work in Taiwan (Formosa) and Queensland has shown that by planting 19,000 plants to the acre instead of 14,000 an increase up to 30 per cent in yield may be obtained—the main extra cost being only the amount of fertilizer used per acre.

In nutritional trials, a comparison is being made with sulphate of ammonia, ammonium sulphate nitrate, and calcium ammonium nitrate to determine whether the nitrate nitrogen is equally effective as ammonium nitrogen or whether the acidification properties of the sulphate of ammonia has a benefit of its own. A study is also being made, by spectographic analysis of the leaves, of the seasonal variation in the nutritional status of the plant with particular reference to nitrogen. This may indicate where economies in nitrogen application may be effected and thereby reduce production costs by more efficient use of fertilizer.

Another trial is being undertaken to study the effect of an application of nitrogen as soon as the plant crop has been harvested, and using a flower induction hormone to complete the ratoon crops—the object being to produce an early and quick ratoon and thereby reduce the duration of the cropping cycle and increase the annual yield per acre. For the same reason the effects of irrigation on yield and length of cropping cycle are also being studied.

Long-term trials have been started on the effect of soil fumigation, ploughing back the plant material at the end of the cropping cycle and finding a suitable inter-cycle green manure crop as a means of restoring fertility and maintaining productivity where successive crops of pineapples are grown. (1) and (2).

Berry and Other Fruits

Strawberries

Rotational/Manurial Trial

The first crop results from this trial were reported in Part II of the Annual Report for 1959. The second crop results are shown in Table 4.

Table 4—Rotation/Manurial Trial (2nd Crop Results)

Mean yields	A	B	C	D	E	Mean
Lb./acre ..	2,468*	2,296	1,764	2,526*	2,226	2,256

(*Significant at P = 0·05)

The treatments were as follows:—

A = 40 tons FYM per acre.

B = 20 tons FYM plus 867 lb. sulphate of ammonia plus 237 lb. double superphosphate plus 409 lb. of muriate of potash per acre each.

C = Green manure grown *in situ* as wheat and ploughed in.

D = Green manure as in C plus 1,235 lb. sulphate of ammonia plus 226 lb. double superphosphate plus 226 lb. of muriate of potash per acre.

E = 6 tons wheat straw plus 1,278 lb. of sulphate of ammonia plus 446 lb. double superphosphate plus 778 lb. muriate of potash per acre.

Yields over the two crops show the superiority of the FYM at 40 tons per acre. The cost of the FYM at Sh. 40 per ton was Sh. 1,600 while the cost of the fertilizer in the D treatment, which shows promise, was only Sh. 352/17 per acre. (3) and (4). In the total of the two crops the A treatment outyielded the D treatment by 696 lb. (3) and (4).

of the treatments on increasing the yields of Grade I fruits. The increase in cash return by virtue of increased yields and better grades of fruit have more than covered the cost of fertilizer in each treatment.

TABLE 3

Treatment	Yield in each grade tons/acre			Total first crop yield tons/acre	Canning price value per acre
	Grade I	Grade II	Grade III		
					£
A Control, Nil	3·2	14·7	1·2	19·1	158
B 420 lb. N	20·1	6·0	Nil	26·1	242
C 525 lb. N	27·8	1·4	0·2	29·4	294
D 420 lb. N	17·1	7·5	0·2	24·8	232
E 525 lb. N	22·9	5·4	Nil	28·3	273
F 210 lb. N	7·4	14·3	Nil	21·7	187
G 420 lb. N	18·3	7·9	0·1	26·3	247
H 420 lb. N	14·7	7·9	Nil	22·6	210
I 525 lb. N	17·1	10·4	Nil	27·5	254
S.E. of means	3·8	2·0	0·2	2·2	26
L.S.D. between treatments 5%	11·1	5·8	0·6	6·4	76

The treatments were as follows:—

A = Control.

B = Sulphate of ammonia (21% N) Solid Soil application at 2,000 lb. per acre (420 lb. N).

C = Sulphate of ammonia (21% N) Solid Soil application at 2,500 lb. per acre (525 lb. N).

D = Urea (46% N) Solid Soil application at 912 lb. per acre (420 lb. N).

E = Urea (46% N) Solid Soil application at 1,140 lb. per acre (525 lb. N).

F = Sulphate of ammonia (21% N) 1½% Foliar Spray at 1,000 lb. per acre (210 lb. N).

G = Sulphate of ammonia, 3% Foliar Spray at 2,000 lb. per acre (420 lb. N).

H = Urea (46% N), 2½% Foliar Spray at 912 lb. per acre (420 lb. N).

I = Urea (46% N), 5% Foliar Spray at 1,140 lb. per acre (525 lb. N).

There are slight indications that sulphate of ammonia is more effective than urea, compared on an equal nitrogen basis, but in no case is the difference so great as to be ascribable to origins other than chance. There is no significant difference between the methods of application but it is clear that no economy can be effected in the amount of nitrogen applied by foliar sprays as opposed to placement soil applications.

Foliar sprays of urea are cheaper to apply than sprays of sulphate of ammonia since for every 100 lb. of N applied it requires four applications of 5 per cent urea, at the rate of 120 gallons per acre, as compared to thirteen sprays of 3 per cent sulphate of ammonia at the same rate of application.

The higher rates of application of both the sulphate of ammonia and urea have given greater returns than the lower ones, but the increases at this stage of the trial are not statistically significant. The full effects of the treatments will have to await the results of the next crop.

Trials Started in 1960

In 1960 trials were laid down to compare different sizes of crowns, slips and suckers to determine their effect on yield and time of harvest. Monthly plantings are also being made with the three types of plant material to investigate the influence

trawberry Costing/Production Trial

The second crop yields are shown in Table 5. The first crop yields were published i Part II of the Annual Report for 1959.

'ABLE 5—STRAWBERRY COSTING/PRODUCTION TRIAL, 1ST AND 2ND CROP YIELDS LB./ACRE

Cropping Period	1st Crop Yield	2nd Crop Yield	Total to Date
st Aug. to 1st Oct. ..	1,970	1,200	3,170
st Oct. to 1st Dec. ..	5,005	1,790	6,795
st Dec. to 1st Feb. ..	4,075	2,620	6,695
st Feb. to 1st April ..	6,660	2,520	9,180
st April to 1st June ..	10,360	4,440	14,800
st June to 1st Aug. ..	4,080	3,650	7,730

The yields show a very marked fall-off over the first crop yields, but the April/ une cropping period has again proved to be the best for heaviest yields. This trial hows that the yield fall-off in imported planting material is quite considerable. 'ruit size is also reduced in the second crop.

When the cost of production figures become available, after the third crop, they re likely to indicate very strongly that replanting with newly imported material each ear, or at most one and a half years, will prove more profitable than cropping over ong periods as has been commercial practice in the past. (3) and (4).

'trawberry Intercropping Trial

An observational trial was planted in April 1959 to study the influence of straw- erries on plum trees when used as an inter-crop. FYM at 10 tons and 20 tons per cre was applied, and the strawberries were planted to within 6 ft. of the trees. The rst crop results are as follows:—

Treatments	Yield/acre (lb.)	Marketable fruit (lb.)
FYM 10 tons/acre	1,138	590
FYM 20 tons/acre	1,160	463

The yields were very low. The age of the planting material, which was splits rom three-year-old plants, and the fact that the plants were unirrigated are thought o account for the poor yields. Nevertheless, a net return at the rate of Sh. 78 per acre esulted. This would have covered the weeding costs of the orchard.

The average yield per tree from the plums was 12·33 lb. for those manured at he 10 tons per acre level, and 14·45 lb. for the 20 tons per acre level. On a yield per cre basis this would result in an increase of 193 lb. for the 20 tons FYM over the 0 tons FYM level. At an average price of Cents 50 per pound of fruit the gross ncrease would be Sh. 85/57 bearing in mind that the manure had already been paid or from the strawberry crop.

Using good planting material strawberries should prove to be a most profitable ntercrop for young plum orchards. (3) and (4).

Strawberry Controlled versus Uncontrolled Cropping Trial

This trial was started in April 1959 using three-year-old splits. There were two reatments as follows: (*a*) Deflowering for 8 months and cropping for 2 months epeated over two crops. (*b*) Deflowering for 3 months and cropping continuously for 7 months.

The yield results are as follows:—

Deflowering for 8 months		*Deflowering for 3 months*
First crop	1,635 lb. per acre	2,288 lb. per acre
Second crop	1,861 lb. per acre	3,837 lb. per acre
	3,496	6,125

Marketable fruit from the second crops were measured and showed 52 per cent for the 8 months deflowered plants and 55 per cent for the 3 months deflowered plants. Though the yields for the plants deflowered for three months have been split into two they were, in fact continuously cropped after the initial deflowering. The figures have been separated to show what the crop yields were at 10 months after planting and 20 months after planting to enable comparison with those deflowered for 8 months and cropped for 2 months repeated over two distinct cropping periods. (3) and (4).

Strawberries—Old versus New Planting Material

A comparison, on a single plot basis, of yields from 3-year-old splits and runners from newly imported plants of the variety Cambridge Favourite has been made. The plants were deflowered for 8 months and cropped for 2 months. The first crop results were as follows:—

3-*Year-Old Splits*	*Newly Imported Runners*
Yield per acre = 431 lb.	11,494 lb.

The results of this experiment should convince any commercial growers of the advisability of using newly imported planting material. (3) and (4).

Strawberry Introductions

Four varieties were imported from Britain in March 1959 for bulking up. During the first year, when the plants were runnering, a count of the number of fruits per pound was made. Cambridge Favourite produced 21 fruits, Cambridge Prizewinner 60 fruits and Cambridge Vigour 64 fruits. A count of Red Gauntlet fruits, which was the other variety imported, was not made.

After the runners were removed the plants were rested and then brought into crop for 2 months and the yield results were:—

Variety	Yield lb./acre	No. fruit/lb.
Cambridge Favourite ..	5,009	76
Cambridge Vigour	1,089	104
Cambridge Prizewinner ..	1,960	128
Red Gauntlet	3,702	76

It is of interest to note that in the Old versus New Planting Material Trial the plants used were the progeny of the Cambridge Favourite referred to under the heading "Strawberry Introductions". The cropping results do tend to indicate that substantial yield deterioration takes place when the parent plants are allowed to runner.

Runnering of newly imported plants, however, is of vital importance if the cost of planting material is to be minimized. From a batch of 1,000 Cambridge Favourite plants imported in April 1960, 5,600 runners were produced by October and were planted out. Not only were 5,000-odd runners produced but a profitable crop of fruit will also result from the original parents. (3) and (4).

YOUNGBERRIES

Yields from a grey vlei soil over a two-year cropping period were as follows:—

First crop = 2,070 lb. per acre
Second crop = 2,900 lb. per acre } not irrigated.

Equivalent yields, from forest loam, for plants at the same age though planted five years earlier was:—

First crop = 6,216 lb. per acre
Second crop = 7,644 lb. per acre } irrigated.

Yields from the forest loam soils have fallen considerably during the seven years the plants have been cropping. The seventh year crop has dropped to 3,098 lb. per acre but even so, at a return of Sh. 2/01 per pound, the crop is still quite profitable. To maintain high yields and profits it would be advisable to uproot and replant every five years because it is at this age that the crop starts to decline. (3) and (4).

SHANK'S BLACKBERRY

The plants were cut back in 1959 for the purpose of inducing shoots for layering. From the new growth the 1960 yield was 13,575 lb. per acre which was considerably less than it was for the two crops produced before the plants were cut back. (3) and (4).

CAPE GOOSEBERRY

The second crop which was produced by cutting the plants back to within six inches of their base was as follows:—

Treatment	Yield lb./acre	Yield plant/lb.
FYM 10 tons/acre	13,092	4·81
FYM 20 tons/acre	11,269	4·14

The first crop results were published in Part II of the Annual Report for 1959.

Of the fruits harvested approximately 23 per cent were of 5 grams weight and above which made them suitable for export. Of the remainder 44 per cent was fit for sale on the local market while the rest were unsaleable.

An attempt to produce a third crop by pruning back for a second time gave very low yields. A two-crop cycle appears to be the optimum especially when considering the export trade. A 10 tons per acre application of FYM is better than 20 tons.

Grapes

A period of pruning trial on Golden Muscat grapes, to cover early and late pruning, has been carried out and the results were as follows:—

Date Pruned	No. bunches harvested	Mean weight per bunch/oz.
19–6–59	47	2·43
7–7–59	42	2·00
20–7–59	38	1·47
4–8–59	20	3·00
18–8–59	25	1·56
1–9–59	15	1·54

On a yield basis, in term of bunches of grapes, the early pruning has proved to be the best. The heaviest bunches were produced as a result of the early August pruning. Bunch weight is extremely light and demonstrates just how unsuitable the Molo climate is for commercial grape production. (3) and (4).

Vegetables

Onions

Cost of Production of Onions

An acre block of the onion variety Bombay Red was grown at Thika to determine the production costs and the net profit likely to be made. A red soil area was prepared by normal ploughing, discing and harrowing, and finally by rolling with a Cambridge Roller to firm and level the soil before sowing. Dieldrin at 2 lb. per acre was applied as a soil dressing before harrowing for termite control. No manure was applied as the land had received a heavy dressing of FYM on a previous crop of beans. The seed was sown direct at 10 lb. per acre on 11–7–60 at a planting distance of 1 ft. between rows. Germination was good and on 9–9–60 the plants were thinned 4 in. to 6 in. apart in the rows. After thinning the area received a side dressing of sulphate of ammonia at the rate of 1 cwt./acre. Overhead irrigation was applied at approx. 1 in. each application, whenever considered necessary. In total the plants received 20·03 in., i.e. Rainfall 10·03 in., Irrigation 10 in. The onions were lifted and left in windrows on 15–12–60, and brought in from the field on 2–1–61. Finally they were graded out, bagged and sold. The onions yielded 3·83 tons and were sold at an average price of 28 cents per lb.

The production costs were as follows:—

	Sh.	*cts.*
Land preparation	42	50
Insecticide, Dieldrin 2 lb./acre	10	91
Marking out, sowing	103	12
Seed, 10 lb./acre	128	00
Thinning	38	95
Fertilizer application, sulphate of ammonia 1 cwt./acre	32	80
Irrigation 10 in. (pumping costs)	67	50
Cultivations	118	00
Lifting, laying in windrows, harvesting	67	00
Grading and bagging	133	00
Packing material at Cents 50 per 60 lb. sack	74	50
Transport cost	89	60
Total Expenditure	907	88
Gross cash return for 3·83 tons at 28 cts./lb.	2,402	18
Less Total Expenditure	907	88
Net Profit	1,494	30

The approx. net profit with onions sown on red soil was therefore £75 per acre.

In another trial on heavy vlei soil an area was direct sown and the thinnings transplanted to double the area originally sown. The direct sown yielded 4·3 tons and the transplants 4·5 tons per acre—the former taking 5½ months and the latter 6½ months to maturity. This crop was sold on the market at an average price of 25 cents per lb. and realized a mean net profit of £69 per acre. (2).

Onion Varieties

Five varieties Bombay Red, Bellary, Texas Grano, Egyptian Flat and Cyprus were compared in a micro-plot trial at Mwea. Of these Cyprus was the only one which did not bulb and can therefore be discarded from future trials. Bellary and Bombay Red were very similar in appearance, yield and behaviour. Texas Grano,

an early maturing soft white variety, and Egyptian Flat gave the best yields, although the latter did not ripen until the start of the rains and many sprouted immediately after harvest. Egyptian Flat holds promise as a new variety for Kenya. (1) and (5).

In a similar trial carried out at Perkerra, Bombay Red gave outstandingly the best yield, and Bellary yielded least. (4) and (6).

Onion Seed Production

A trial was laid down in the Long Rains 1960 at Mwea to test the effect of two rates, 1 cwt. and 2 cwt. per acre, of sulphate of ammonia, and two spacings 18 in. by 3 in. and 18 in. by 6 in. on the production of seeds and bulbs from onion bulbs of the variety Bombay Red. The bulb size was 1½ in. to 2 in. diameter and approximately 8,064 lb. and 4,032 lb. respectively of planting material per acre was required.

In this trial all the bulbs divided into four before flowering, and only a small proportion of the bulbs so produced ran to seed; this resulted in the production of a very heavy crop of ware onions as well as the seed. The mean yield, clean, dry seed and saleable bulbs from each treatment is given in the following Table:—

Table 6

Plant Spacing	Clean Dry Seed Lb./Acre		Saleable Bulbs Tons/Acre	
	1 cwt./acre S/A	2 cwt./acre S/A	1 cwt./acre S/A	2 cwt./acre S/A
18 in. by 3 in.	275·0	280·0	9·43	11·39
18 in. by 6 in.	233·0	237·0	7·52	6·44

There was no significant difference between the treatments on the yield of seed, but in the analysis of saleable bulbs the 18 in. by 3 in. spacing significantly (P —·0001) outyielded the 18 in. by 6 in. spacing. No other treatment or interaction gave a significant difference. (1) and (5).

Observational Trials at Perkerra

Several observational trials were carried out to investigate the most suitable size of set to plant for production of ware onions, and the most suitable size of bulb to plant for seed production, together with the effect of storage before planting at Molo and at Perkerra on each.

The results indicate that storage of seed bulbs for a period of several weeks at mean temperatures considerably lower than those in the area in which they are afterwards to be grown helps to initiate flowering. A suitable size of bulb to plant for seed production is 1 in. to 1½ in. or larger in diameter. Conversely, the size of set for planting in order to produce ware onions, when the maximum inhibition of flowering is required, should not exceed 1 in. in diameter. (4) and (6).

Asparagus

At Thika the abnormal condition of asparagus spears, described in the Annual Report for 1959, has continued, and all attempts to solve this problem have failed.

Monthly Cutting Trial—Molo

The fourth-year results are shown in Table 7. The results of the third-year crop were published in Part II of the Annual Report for 1959.

Table 7—Asparagus Monthly Cutting Trial—Fourth-Year Results

Treatments	Yield lb./acre	Mean Soil temp. 1 ft. °F.	Mean air temp. °F.	Rainfall inches
May	941·1	63·7	57·6	6·70
June	552·0	64·3	55·4	2·11
July	345·0	62·2	54·5	3·02
August	387·7	61·3	55·1	6·10
September	794·8**	63·9	53·9	2·98
October	351·9	63·8	56·1	2·76
November	31·7	62·5	56·2	4·13
December	204·2	63·7	56·3	1·71
January	972·9**	64·6	57·7	1·01
February	361·5	65·0	58·1	0·44
March	692·7**	63·0	58·8	4·55
April	779·9**	63·7	58·6	4·66
Means	497·1	65·1	57·3	3·37

(**Significant at P=0·001)

An analysis of the yield results, and other data, over the four years cropping period has shown that air temperatures and rainfall are not correlated with yields but there was correlation between the logarithm of the yield, and the mean soil temperatures and hours of sunshine.

The general conclusion is that factors of soil temperature and hours of sunlight are most clearly associated with yield increase and it also seems sensible that rainfall and air temperatures are also, but in a more complex fashion, having some influence on yields as well.

The best average yield over the four years was during March and April, giving 1,493 lb. per acre. About one-third of the crop was considered unsaleable. The 996 lb. which was saleable averaged Sh. 2/52 per pound or Sh. 2,509 per acre. Production costs worked out at Sh. 1,144 per acre giving a net return of Sh. 1,365 per acre, per year. (3) and (4).

Asparagus Fertilizer Trial

The second-year crop results are shown in Table 8. The first-year crop results were published in Part II of the Annual Report for 1959.

Table 8—Asparagus Fertilizer Trial—Summary of Second Crop Yields

Treatments	FYM	NPK	N	Mean
Yield per acre/lb.	631·8	557·7	513·5	567·6

The results were not significant though there was a tendency for FYM to increase yields. The yields so far obtained from this trial are considered too low to be economic. Since crown die-out is not high, as yet, there is a possibility that yields may improve as the plants become more mature.

Asparagus Variety Trial

The first crop results are as follows:—

Variety	*Yield lb./acre*
Purple Argenteuil	605
Connover's Colossal	715
Battersea Giant	825

The yields compare with those of a first crop of the variety Mary Washington which is growing in close proximity, and on an identical soil type. Had it not been for an extremely high crown death rate of 69 per cent the yield of Purple Argenteuil would undoubtedly have been heavier. (3) and (4).

Asparagus Cropping Trial (Kitale)

The fifth-year yield was 3,231 lb. which is the highest so far recorded for the trial. The soil temperature, at 1 ft. depth, during the harvesting period was 72·7 degrees which was 9·6 degrees higher than at Molo for the same period. The yield results for the previous years were published in Part II of the Annual Report for 1959. (3) and (4).

PEAS

Seed Dressing Trial

This trial was put down in April 1960 at the request of the Senior Plant Pathologist, to test various chemicals and their effect on germination. The variety used was Onward spaced at 4 in. in the row with 1 foot between the rows. The period from sowing to harvesting was 16 weeks and the rainfall during the period was 10·29 inches. The treatments, germination and yields in the pod are shown in Table 9.

TABLE 9—PEA SEED DRESSING TRIAL

Treatments	Strength	Per cent Germination 17 days after	Yield lb./acre
Nil	Nil	37	6,184
Thiram	5,000 ppm	64	7,786**
Thiram	2,500 ppm	53	9,406**
Thiram	1,250 ppm	49	7,438
Captan	2,500 ppm	74**	6,532
Captan	1,250 ppm	81**	8,866**
Captan	625 ppm	81**	9,563**
Organo Mercury	50 ppm	51	5,400
Organo Mercury	25 ppm	44	5,313
Organo Mercury	12·5 ppm	43	5,260
Spergon	5,000 ppm	58	9,581**
Spergon	2,500 ppm	59	7,298
Spergon	1,250 ppm	64	7,612
Inoculated	—	30	4,442
Silver Nitrate	—	30	1,742

(**Significant at P = 0·001) (3) and (4)

Cauliflower Curding Trial

A trial was started in October 1959 and covered a period of almost 10 months. The object was to study the influence of fertilizers and manure on curding and yields. The variety used in the trial was Southern Cross. The treatments were FYM at 10 tons per acre, triple superphosphate at 100 lb., sulphate of ammonia at 400 lb. and

sulphate of potash at 100 lb. per acre each. The mean yield for the single factor elements were as follows:—

Cauliflower Curding Trial (Yield Results)—Means of 16 Plots

Treatments	*Tons/acre*
(1)	5·50
N	5·35
P	5·54
K	5·63
FYM	6·22

There was a significant increase in yield at the 5 per cent level as a result of the application of FYM.

Potatoes

Fertilizer Trial

This was a follow-up on a trial conducted in 1959 the results of which were published in Part II of the Annual Report for that year.

The trial was planted in May and covered a period of 15 weeks. Rainfall during the period was 12·78 inches of which 5·67 inches fell during the last three weeks of the trial when it was of no benefit to the crop.

The variety used was Rosslin Elementaita. (E 52.)

FYM at 15 tons per acre resulted in a highly significant increase in yield. The other treatments were triple superphosphate at 1 cwt. and 2 cwt. per acre and muriate of potash at 2 cwt. per acre. Yields were low but were attributed to two serious drought periods which occurred during the trial. (3) and (4).

Potato Bulking

Potatoes have been grown at Molo for observation and bulking. Two crops were taken during the year, one crop during the dry season and the other during the rainy season. The yield results are shown in Table 10.

Table 10

Variety	Yield from Oct./Mar. crop tons/acre	Yield from May/Oct. crop tons/acre	Variety	Yield from Oct./Mar. crop tons/acre	Yield from May/Oct. crop tons/acre
Voran	7·66	7·18	Record (A.55)	4·07	8·02
Van Haeringen ..	7·15	8·42	Ulster Emblem (D.55) ..	3·68	6·48
Alpha	4·71	3·51	US.1	10·98	17·94
Profijt	2·62	2·36	US.2	7·68	14·99
Pimpernel ..	4·10	12·10	US.3A ..	7·59	15·15
Gineke	6·72	7·77	US.3B	9·63	14·95
Brokema ..	6·50	13·45	US.4	4·34	9·30
Ambassadeur ..	5·03	10·46	US.5	5·82	15·38
Loman	5·75	15·65	US.6	13·27	19·62
Dekama	5·62	16·90	US.7	7·40	11·88
Tedria	5·51	15·55	US.8	14·75	21·37
Rival	5·98	16·26	US.10	11·38	13·31
B.55	5·60	7·11			
C.52	9·87	Not grown			

Rainfall for the Oct./Mar. crop was 10·86 inches and for the May/Oct. crop 18·38 inches. The soil in which the potatoes were planted was good and 1½ cwt. triple superphosphate was applied at planting time. (3) and (4).

Miscellaneous Crops

Mushrooms

A trial was started in July 1959 to test a synthetic compost based on that recommended by the United Kingdom's Mushroom Research Association.

The trial covered a period of 7½ months. The compost was made up into beds on an earth floor of a darkened ventilated building. Cropping commenced 37 days after spawning and continued for 4 months.

The yield from 115 square feet of bed was as follows:—

1st month	60 lb.
2nd month	54 lb.
3rd month	43 lb.
4th month	49 lb.
Total	206 lb.

The yield per square foot of bed was 1·79 lb. which was just below the minimum average yield produced in Britain. An average price of Sh. 4/65 per pound was realized for the crop. The half ton of synthetic compost used in the trial cost Sh. 162 which is out of all proportion to the cost of good horse manure which is not expected to cost more than Sh. 20 per half ton. (3) and (4).

Chicory

Chicory Variety Trial

Nine varieties were sown *in situ* in April 1959 at a spacing of 18 inches between the rows thinning to 9 inches in the row when the plants were large enough to handle. The period from sowing to harvesting was almost 5 months. Rainfall during the period was 20·57 inches. The varieties and yields were as follows:—

Varieties	*Yields lb./acre*
Large rooted or coffee	19,131
Long rooted (English)	24,902
Ex Bathurst (South Africa)	22,243
Long rooted improved Vilmorin	22,014
Large rooted long smooth	12,894
The Productive (large rooted)	10,857
Port-de-Pierre	25,242
Ex Dunns (France)	21,350
Port-de-Pierre, Selection 19203	19,364

Samples were sent to Messrs. Brooke Bond (E.A.) Ltd., Kericho for assessment. Only the varieties The Productive, Port-de-Pierre Selection 19203 and Long rooted improved Vilmorin were considered comparable with the varieties grown by Brooke Bond in Kenya. (3) and (4).

Geranium

Propagation Trial

Because of difficulties experienced in establishing cuttings in the field a trial was undertaken to study methods of preparing cuttings with a view to improving rooting. Half the cuttings in each treatment were dipped in an 0·5 per cent Orthocide Captan solution in order to inhibit fungus infection.

The treatments and rooting results are shown in Table 11.

TABLE 11—GERANIUM PROPAGATION TRIAL

Treatments	Per cent rooted undipped	Per cent rooted dipped
Nodal cut	Nil	2
Internodal cut	Nil	Nil
Nodal cut and treated with Seradix No. 2	16	34
Internodal cut and planted on ridged soil	Nil	Nil
Nodal cut. Leaf petioles left long	2	Nil
Nodal cut. Planted in sand	2	2
Nodal cut and then split through vertically	4	Nil
Internodal cut and treated with Seradix No. 2	16	46

All the cuts were made in newly ripened wood. Most of the cutting material was considered to be extremely poor quality and had been extensively bruised. Nevertheless the results of the trial show an overwhelmingly favourable influence of the root hormone Seradix No. 2 when used in conjunction with Orthocide Captan.

A repeat of this trial, when the cuttings were prepared and planted by semi-skilled labour, produced disappointing results. The Seradix No. 2/Orthocide Captan treatment produced only 18·3 per cent rooting and the Seradix No. 2, by itself, resulted in 3·6 per cent rooting while the Orthocide Captan by itself gave 2·36 per cent rooting. The indications are that while a Seradix/Captan treatment can be of immense assistance in rooting cuttings it will not overcome the problem of poor craftsmanship in the preparation and planting of the cuttings which are the factors believed to have contributed to poor rooting in the repeat trial. (4).

T. H. JACKSON,
Senior Horticultural Research Officer.

Publications

Jackson, T. H.—Onions can be profitable as a side line. The Kenya Sisal Board Bulletin No. 33, July 1960.

Evans, H. R. and Blandy, R. V.—Pineapples—Notes on Cultivation and economics of production. The Kenya Sisal Board Bulletin No. 34, October 1960.

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(2) T. H. Bannister, Assistant Horticultural Officer, Ministry of Agriculture, Horticultural Research Station, P.O. Box 220, Thika.

(3) H. R. Evans, Senior Assistant Horticultural Officer, Ministry of Agriculture, Horticultural Research Station, P.O. Box 100, Molo.

(4) D. C. Attenburrow, Assistant Horticultural Officer, Ministry of Agriculture, Horticultural Research Station, P.O. Box 100, Molo.

(5) J. M. Suttie, Agricultural Officer (R), Ministry of Agriculture, Mwea/Tebere Irrigation Scheme, Private Bag, Embu.

(6) R. G. M. Hossen, Assistant Agricultural Officer (E), Ministry of Agriculture, Perkerra Research Station, P.O. Marigat via Nakuru.

ANNUAL REPORT OF THE SENIOR PYRETHRUM OFFICER, 1960

1. Meteorological

Detailed meteorological data for the individual pyrethrum research centres will be published in a more comprehensive report edited by the Pyrethrum Board of Kenya.

The dry period intervening between the two growing seasons 1959 and 1960 was long enough to ensure a satisfactory build-up of soil nitrogen and when good rains fell towards the end of March and in April, prolific flowering was stimulated. Unfortunately, after the beginning of May the rainfall pattern was very irregular, some areas receiving their normal quota or more, others remaining exceptionally dry. Amongst these was the Molo research station where the water supply reached a critical stage towards the end of the year and many field trials dried up by November. Only in a few places, such as the Kinangop and Mau Narok effective rains were recorded later than August. Quite a number of April plantings failed due to drought conditions in May, June and July. In spite of these adverse climatic factors the overall yields in pyrethrum flowers received a further boost over the 1959 production which was due chiefly to larger acreages planted in 1959. The deliveries to the Pyrethrum Board amounted to 19,083,346 lb., 7,972,630 lb. more than in the preceding season. The pyrethrins contents over all areas were satisfactory up to July—as the result of generally good rains in March and April—averaging 1·49 per cent. But beginning with the August pickings, a severe drop in toxic content was recorded and this is most likely attributable to the erratic rainfall causing a general rise in mean temperatures. The mean content over the twelve months was only 1·42 per cent as compared with 1·54 per cent in 1959 and this again would confirm the results of mathematical calculations which proved a close interrelation between mean temperatures and the production of pyrethrins by the plant. The climatic conditions did not favour heavy outbreaks of bud diseases, neither the physiological form nor the one caused by the fungus *Ramularia bellunensis*. They occurred only in certain areas over comparatively short periods of cloudy and wet weather. Thrips infestations became more common towards the end of the season.

2. Experimental Work

(*a*) Fertilizer Trials

Twelve experiments incorporating fertilizers and manures were either maintained or laid down.

The trial on A. James' farm, Mau Summit, on rather poor and red soil completed three seasons and produced the following overall results (lb./acre dry flowers):—

Main Effects and Interactions

(1)	2,329
P	+679**
K	−22
Ca	+162
PK	+240*
PCa	+51
KCa	−76
PKCa	−178

**significant at P=0·01
*significant at P=0·05

(P=200 lb./acre Triple Supers. K=100 lb./acre Muriate of Potash. Ca=3 tons/acre Ground Limestone.)

Lime had a statistically significant effect (P=0·05) only in the second season which can hardly be considered economic.

On a very acid soil of the High Bracken zone above Embu lime and superphosphate had a persistent effect for three years while farm yard manure produced a yield increase in one trial and a depression in yield in the second; this last effect is difficutt lo understand. These experiments were conducted by Mr. M. E. H. Vickers, Agricultural Officer (Experiments), Embu.

Similar Bracken soils are encountered at Upper Molo in the Sitoten area where pyrethrum yields normally are rather disappointing. An experiment was planted on Dixon and Dixson's farm in collaboration with Mr. G. Stern, Agricultural Officer, Kericho, in the hope of finding out more about the nutritional requirements of these soils. Yields (lb./acre dry flowers) in the first season were:—

Main Effects		2-Factor Interactions	
(1)	247	Ca, $MgSO_4$	−10
Ca	+65	Ca, $CaSO_4$	−52
$Mg SO_4$	−47	Ca, P	−40
$Ca SO_4$	+114*	$MgSO_4$, P	+72
P	+57	$CaSO_4$, P	−45
FYM	+48	Ca, FYM	−3
		$MgSO_4$, FYM	−27
		$CaSO_4$, FYM	+114*
		P, FYM	−53
		$MgSO_4$, $CaSO_4$	−52

*significant at P=0·05

(Ca=3 tons/acre ground limestone, $MgSO_4$=100 lb./acre Kieserite, $CaSO_4$=220 lb./acre Gypsum, P=200 lb./acre Triple Supers., FYM=10 tons/acre farmyard manure.)

Most surprising is the response to Gypsum which is difficult to explain as neither heavy applications of lime (Ca) nor the sulphur contained in Kieserite have shown an effect. Further investigation of this mineral is desirable. The response to phosphorus is disappointing for this soil type.

On Schalch's farm, Thomson's Falls, an experiment was planted in 1959 and has now completed two seasons. The soil is of reddish colour and of the high-altitude leached type where one would expect an economic response to phosphatic fertilizers and possibly to liming. The 1960 records show the following:—

Main Effects and Interactions	
(1)	445 lb./acre
P	+488***
K	−24
Ca	+103
PK	+41
PCa	+43
KCa	−84
PKCa	−97

***significant at P=0·001

(P=200 lb./acre Triple Supers., K=100 lb./acre Muriate of Potash, Ca=3 tons/acre ground limestone.)

(*b*) Rotation Trial

A large experiment had been designed by the Statistical Department at Rothamsted and then started on the Ol Joro Orok Experimental Farm in 1947. The main object was to determine the most suitable place for pyrethrum in a balanced mixed farm rotation. Pyrethrum is planted alternating with cereals and/or grass leys at different combinations, each crop to stay in the ground for three seasons. The Control consists of plots on which pyrethrum is being grown continuously, i.e. replanted in the same place every three years. Grass leys are grazed by sheep and the continuous pyrethrum and some other plots are subdivided for different manurial treatments. It was soon

evident that the structure of the top layers of the soil in the continuous pyrethrum plots deteriorated and that run-off after heavy rainfall was encouraged. The pyrethrum flower production however showed no sign of decline in these plots as compared with the yields obtained from pyrethrum which was rotated with other crops. This state of affairs lasted for 12 years but after this period there were signs of yield reductions in the Controls and during 1960 these were further accentuated. Especially pyrethrum following two grass leys (i.e. grass for 6 years) yielded very much better than continuous pyrethrum ($P=0{\cdot}001$) and more heavily than in the rotation: Pyrethrum, Cereals, Grass ($P=0{\cdot}01$).

(*c*) Weedkiller Trials

Assisted by Mr. S. D. Hocombe, the Botanist of the Tropical Pesticides Unit at Arusha, two extensive experiments were laid down in April and July respectively. Altogether 21 new compounds were tested most of which, if at all effective against broad-leafed weeds, were harmful to established pyrethrum plants and in many cases depressed the production of pyrethrins. However, a few of these chemicals as Amoben and Kerosene are worth further trials. For nursery work, i.e. as a treatment before the sowing of the seed, Eptam at the rate of 3 lb. active agent per acre either in liquid (78 per cent) or granular (5 per cent) form showed great promise.

(*d*) Drying Tests

A series of drying tests was carried out at Ol Joro Orok with large samples (50 lb.) of flowers from clone 194. Sundrying was compared with drying in the "Drycom" drier at temperatures from 175° to 180° F. If flowers are removed immediately they are dry, then there is no loss in pyrethrins at these comparatively high temperatures. Over-drying however reduces the toxic content considerably. A special report on the tests will be published separately.

3. Plant Breeding

Within the routine work of producing new varieties, 194 new single plant selections were made at the four main research centres while a total of 557 was under observation. 86 clones which had shown promise over the last three seasons in the breeding plots, were bulked up. 39 small isolated plots were kept for the production of new hybrids (two-clone crosses) and the polycross "Sugar Beet" breeding systems at Molo and Subukia were continued in 14 larger isolation plots. The first seed issues from these polycrosses were made. The effort to step up seed production in general was maintained by either the enlargement of existing or the planting of new seed fields and there are now altogether 31 plots on research stations and private farms from which seed of 28 different varieties is being harvested. Over the year, 8,493 lb. of seed were delivered to the Pyrethrum Board, i.e. 3,259 lb. more than in 1959. Spread over a considerable range of the pyrethrum growing areas twenty-two yield trials were maintained or planted in which new hybrids were tested for their behaviour under varying climatic conditions. In the trials which had been planted in 1958 and have now completed three seasons, M.55, M.65, O.21 and O.31 have shown the greatest promise and are eligible for issue from 1961 onwards.

U. KROLL,
Senior Pyrethrum Officer.

ANNUAL REPORT OF THE OFFICER IN CHARGE SISAL RESEARCH, 1960

Meteorological

RAINFALL AT THE SISAL RESEARCH STATION, THIKA

	1960	Average, previous 19 years
January	0·75″ in 2 days	1·25″ in 3·3 days
February	0·24″ in 2 days	1·44″ in 2·7 days
March	9·95″ in 16 days	3·35″ in 7·2 days
April	6·62″ in 10 days	8·50″ in 15·2 days
May	0·43″ in 4 days	5·26″ in 11·8 days
June	— —	0·99″ in 4·8 days
July	0·83″ in 3 days	0·61″ in 3·7 days
August	0·23″ in 1 day	0·65″ in 4·5 days
September	1·38″ in 5 days	0·62″ in 3·1 days
October	2·85″ in 6 days	1·69″ in 5·0 days
November	2·81″ in 6 days	5·66″ in 14·5 days
December	1·71″ in 7 days	3·09″ in 8·9 days
Total	27·80″ in 62 days	33·11″ in 84·7 days

The average rainfall for the 20 years recording at the Station is 32·84″ in 83·7 days. Less than 30″ was recorded in 9 of the 20 years.

SALE OF FIBRE

The fibre produced at the Station during 1960 amounted to 16,947 lb. line fibre, 445 lb. brushed tow and 444 lb. flume tow, which was sold locally, realizing the sum of £645 which was paid to the Kenya Sisal Board.

Investigational Work in Progress

NURSERY TRIALS

In the irrigated Nursery Trial each cycle is 12 months and the 4th cycle was lifted in 1960. There was no response to irrigation during the first 2 cycles, there was a small (P=0·05) significant response in the 3rd cycle, and a slightly bigger one in the 4th cycle.

AVERAGE WEIGHT OF PLANTS IN LB.

	1st Cycle	2nd Cycle	3rd Cycle	4th Cycle
With irrigation	1·87	1·96	1·88	1·97
Without irrigation	1·77	2·19	1·67	1·64
Effects	0·10	−0·23	0·21	0·33
Rainfall	36·74″	46·66″	32·94″	30·20″
Water added	5·00″	13·00″	16·00″	29·00″

The increased effects of irrigation must be partly due to the increased amount of water added, but also partly due to a different method of application. In the first 2 cycles the water was added for short periods; the periods were prolonged in the 3rd cycle and in the 4th cycle watering was done during the late afternoons and early mornings.

Applications of sulphate of ammonia increased the plant weight significantly in the first cycle only; significant responses have been obtained from 30 tons sisal waste in all 4 cycles.

The second cycle of the trial comparing the effect on bulbil nurseries of 50 tons Farm Yard Manure per acre to 50 tons of sisal waste was lifted during the year. The responses were outstanding, this being partly due to the inherently low fertility of the area on which this trial is planted. The average plant weight in the untreated plots was 2½ lb. which an application of sisal waste more than doubled and the Farm Yard Manure more than trebled, and there is a suggestion that the fertility is building up under Farm Yard Manure, in spite of the great weight of plants removed. These treatments are tested in the presence and absence of Nitrogen and Lime. The response to Nitrogen was small but significant when added to Farm Yard Manure. The response to Lime was, in all cases, a depression in the plant weight.

The first cycle of a Nursery Trial testing P, K and S on soil of low fertility was lifted and all treatments showed an increase in plant weight from 2½ lb. to 3 lb. None of the interactions were significant but the response to S (as Gypsum) warrants further study.

Two new Nursery Trials were planted during the year, one to investigate Sprinkler irrigation and a 2^5 factorial for sisal waste, N, S, P and Mg.

Plant Management Trials

The last 2 external Spacing and Cutting Trials in the series of 5 trials planted 1948 and 1949 were cut out during the year. There is nothing new one can add to the report of these trials in the Annual Report for 1959.

The following new trials were planted in 1960:—

Planting Trimming Trial to study the effect of leaf and/or root trimming of Nursery plants before transplanting into fields.

Spacing and Population Trial on Black Cotton soil to see the differences in growth of 1,200–1,600–2,000 and 2,400 plants per acre planted in double rows 13 ft. + 3 ft. and single rows 13 ft. apart.

Interplanting Trials

Young trials are in progress to ascertain the effect of introduced grasses and leguminous cover crops in the wide rows between the sisal lines.

During the year two new trials were planted with pineapples as intercrops. The pineapples were spaced normally for fruit production and very close in an attempt to elongate the leaves for fibre production.

Older trials have shown that competition by an introduced grass (*Melinis minutiflora*) was small and negligible for the first two years after which competition was severe for 3–4 years. This was reflected in a smaller number of leaves being produced on the sisal plants where the grass was planted. The competition is reduced later on when the sisal plants have, presumably, developed their root system fully. It follows that intensive cleaning work in the sisal rows which is usually done during the first years of sisal growing could be delayed till the 3rd and following years. It is assumed, of course, that the area around the base of the plants is kept clean from the start up till the time when handweeding becomes impossible due to the size of the plants.

Fertilizer Trials

The Station is at present conducting 8 fertilizer trials planted prior to 1957 and therefore in the fibre-producing stage, five other trials are still in the unproductive stage and three are scheduled for planting early in 1961.

In none of these trials are the quantities which are applied to the soil as big as the estimated removal of nutrients by a sisal cycle because the cost of such applications would be prohibitive to sisal growers. The small responses obtained from such

fertilizers as Phosphate, Lime and Potash are at present only of academic interest and more research is needed to ascertain the reason for the small responses, which may be due to placement, time of application, manner of application, etc.

The response to 107 tons of sisal waste applied in our first fertilizer trial was encouraging but is a completely uneconomic application in practice. There were no visible signs of the waste after 2–2½ years, so investigations were instigated to find the effects of lower initial applications followed by repeat applications after the sisal had been planted.

The first of these trials was planted on rather exhausted sisal soils in the Kitale district in July 1953 with initial sisal waste applications of Nil—25 tons—50 tons and 100 tons and with a repeat application 3 years 9 months later of Nil—75 tons—50 tons and Nil. The average numbers of leaves grown per plant before the repeat application were 92, 93, 99 and 104 and the number of leaves grown per plant during the three years following the repeat applications varied only from 56—55—55 to 54, so it is obvious that the greatest effect from an application of 100 tons of sisal waste is achieved if the whole dressing is done at planting.

Sisal waste applications at Voi which were done in March 1954 at rates of Nil, 12½ tons, 25 tons and 50 tons per acre, had very little effect and the same was the result of an application made in 1955. The small effects were due to the extremely low rainfalls during those years. In February 1957 the total number of leaves grown per plant were only 47·7, 47·7, 48·5 and 54·8 respectively. A third waste application, followed by reasonable rains, induced a further number of leaves during the following 3½ years at the rates of 71·0, 77·4, 77·7, and 89·7. Although there have been reasonable responses to 12½ tons and 25 tons of sisal waste these would hardly be justified when the result from application of an extra 25 tons, making the rate 50 tons is so spectacular. The population is 1,980 plants per acre, so at the application of 12½ tons of waste an extra 12,572 leaves have been grown. There have been an extra 13,252 leaves for 25 tons waste, but for 50 tons of waste the figure is 37,226.

The picture is the same in the other two trials of this kind in Ruiru on murrum soils and on the sandy soils of Kampi ya Moto. The initial application gives the biggest boost to plant growth, applications less than 50 tons of sisal waste per acre result in very limited increases in leaf growth, and if repeat applications are to be considered they must not be at rates of less than 50 tons of sisal waste.

The rate of growth of leaves in the fertilizer trial at the Station, where only initial applications were given, looks as follows:—

Waste application October, 1954 ..	Nil	25 tons	50 tons
Leaves grown per plant—			
1st year	29·4	33·3	36·6
2nd year	38·0	39·6	41·1
3rd year	32·6	32·1	32·9
4th year	26·4	26·1	27·3
5th year	21·9	22·0	22·9
6th year	19·5	19·4	20·5
Total after six years	167·8	172·5	181·3

Again it can be seen that the application of sisal waste induces an initial fillip which lasts for about 2–2½ years after which the plants will produce leaves at the same rate as the untreated plants, and any effect one may see to a repeat application after 2½ years is in fact due to that repeat application and not due to a residual effect from the initial application.

In a trial planted at Donyo Sabuk in March 1957 a comparison is made between n initial application, an application after 18 months and an application at first cut. he trial is due to be cut early in 1961 so the third application has not yet taken place nd the results can be portrayed as follows:—

Vaste applied March 1957	Nil	50 tons	Nil	Nil
eaves grown per plant till Sept. 1958	37	47	37	37
Vaste applied October 1958 . .	Nil	Nil	50 tons	Nil
eaves grown till December 1960 . .	63	62	86	63
otal leaves after 3 years 9 months . .	100	109	105	100

The effect of the initial application has worn off, and the effect of the 2nd applica- ion over a slightly longer period is smaller.

The beneficial effect of nitrogen applications has been mentioned in previous eports. The benefit is not only in greater leaf number and longer leaves per plant ut is reflected in the fibre yields. Till recently all trials with nitrogen were given ulphate of ammonia but during 1960, three trials were planted to compare the effect f various rates of ammonium sulphate nitrate, calcium ammonium nitrate, urea and CD-urea with sulphate of ammonia.

A 2^5 factorial fertilizer trial was planted in December on black cotton soils in Ruiru, the first fertilizer trial on such soils. This work has been delayed till the problem of drainage has been, at least partly, solved.

Hybrid and Varieties Trials

Collection of bulbils from promising plants continues in preparation for a future manurial hybrid trial.

Multiplication of Hybrid 11648 continued during the year, and 420 plants were obtained from rhizomes cut into lengths of which each contained a leaf bud.

Sucker collection from promising non-flowering sisal plants is being continued for further observation.

Herbicide Trials

The amount of work was restricted during 1960 due to the absence of one officer for more than eight months.

Toxicity experiments on bulbil nurseries testing the Butyl Ester of 2,4–D, the Amine salt of 2,4–D, M.C.P.A. and C.M.U. showed that the only herbicide one could safely recommend on sisal nurseries is M.C.P.A. at not more than 1 lb. acid equivalent per acre. 2,4–D (Ester) and 2,4–D (Amine) caused growth disturbances even at low doses of 1 lb. while C.M.U. although not so damaging, caused unevenness in the plants.

Experiments with dalapon at $7\frac{1}{2}$ and 15 lb. per acre sprayed on nursery plants caused a marked phytotoxic effect and the recommendations must be to clear the land of "couch" grasses by heavy dalapon doses (at least 10 lb. per acre) before planting the bulbils.

Of the herbicides under trial in an attempt to keep clean land clean dalapon in combination with Simazine or E.P.T.C. show promise and more work on these lines is envisaged.

Publications

January 1960—"Detailed Estate Plans", Part III, by K. Lerche.

April 1960—"Detailed Estate Plans", Part IV, by K. Lerche.

April 1960—"Some Factors in Brush-room Efficiency", by K. Lerche.

July 1960—"Labour Saving Knives", by K. Lerche.

July 1960—"A New Squeezer for Flume Tow Recovery" by K. Lerche.

October 1960—"Spacing and Cutting Trials", Part I, by K. Lerche.

October 1960—"Planters' Day, Mlingano, 1960", by K. Lerche.

All in Kenya Sisal Board Bulletin.

K. LERCHE,
Agricultural Officer (*Research*).

IRRIGATION INVESTIGATIONS, 1960

Irrigation Research Station, Mwea/Tebere, Embu

Weather Conditions

The total rainfall for the year was 23·23 inches, the lowest figure in six years of recording.

The rainfall was as follows:—

Month	Inches	Days
January	0·15	1
February	0·62	2
March	4·12	11
April	4·87	18
May	3·09	8
June	0·16	2
July	0·13	2
August	0·07	1
September	0·03	1
October	3·77	7
November	3·72	8
December	2·50	7
Total	23·23	68

Rainfall intensity, air temperature, evaporation and sunshine records were kept throughout the year.

Rice Varieties

The variety collection, which was started in 1956, was continued but in order to reduce work and save space only varieties of high quality and yield are now being maintained.

Rice Fertilizer Experiments

The 3^3 fertilizer trial which was started in the Long Rains of 1958 was continued but was modified in so far that the spacing treatments were dropped and organic matter treatments—straw and farmyard manure—introduced to the design. In the Short Rains of 1959 growth was very poor and the only significant response was to the application of 2½ tons/acre of farmyard manure which outyielded control by 300 lb./acre significant at P=0·05.

The results are summarized in Table I.

Table I—Mean Yield of Dry Paddy in Lb./Acre

N_0	1 cwt./acre Sulphate of ammonia	2 cwt./acre Sulphate of ammonia
2,178	2,352	2,380
P_0	1 cwt./acre supers	2 cwt./acre supers
2,375	2,334	2,380
0	Straw returned	2½ tons/acre F.Y.M.
2,115	2,380	2,415

L.S.D. at P=0·05=±283 lb./acre.

In the Long Rains 1960

In the Long Rains of 1960 a significant (0·01) response was obtained to 1 cwt./acre sulphate of ammonia and a further cwt./acre gave a further significant response (0·001). Application of 1 cwt./acre of double superphosphate did not give a significant increase in yield but application of 2 cwt./acre gave a response significant at P=0·05. Application of 2½ tons/acre of farmyard manure gave a response significant at P=0·05. The results are summarized in Table II.

Table II—Mean Yields of Dry Paddy in Lb./Acre

N_0	1 cwt./acre Sulphate of ammonia	2 cwt./acre Sulphate of ammonia
2,452	2,683	3,013
P_0	1 cwt./acre supers	2 cwt./acre supers
2,598	2,730	2,873
0	Straw returned	2½ tons/acre F.Y.M.
2,582	2,730	2,837

L.S.D. at P=0·05 =±149 lb./acre
at P=0·01 =±200 lb./acre.
at P=0·001=±265 lb./acre.

The trial to compare various types of phosphates continued in the Short Rains of 1959. Again there was no significant response to phosphate or between types of phosphate but there was a marked response to sulphate of ammonia significant at P=0·05.

The results are summarized in Table III.

Table III—Mean Yields of Dry Paddy in Lb./Acre

Double Superphosphate ..	2,044	
Hyperphosphate	2,031	
Soda Phosphate	2,063	Main plots
Basic Slag	2,099	
Uganda Rock	2,051	
Nil	1,990	
Sulphate of ammonia ..	2,134	Sub-plots
No sulphate of ammonia ..	1,940	

L.S.D. between sub-plots means at P=0·05=±114 lb./acre.

A further trial was laid down to study the effect of time of application of 1 cwt./acre of sulphate of ammonia on the yield of rice.

There was a significant response at P=0·05 to 1 cwt./acre sulphate of ammonia but the times of application did not differ significantly.

The results are summarized in Table IV.

TABLE IV—TREATMENT MEANS IN LB./ACRE DRY PADDY

Treatment ..	Control	At planting	3 weeks	9 weeks	Flowering
Yield ..	1,764	2,256	2,154	2,124	1,938

Mean of N treatments 2,118 lb./acre.

It will be noted from Table IV, however, that there was a steady non-significant decrease in response to the later applications.

SUGAR CANE

Cane has been grown extremely well on the red soils and plots cut in April 1960 gave a mean yield of 60 tons/acre.

J. M. SUTTIE,
Agricultural Research Officer.

Galole

At Galole, four half-acre plots of U.K.51, four half-acre plots of U.K.58 and eight half-acre plots of I.C.58 were laid out, with a spacing of 3 ft. by 1½ ft.

TABLE V—MEAN YIELD OF SEED COTTON IN LB./ACRE

U.K.51	1,137·9	±150·7
U.K.58	1,086·3	± 66·3
I.C.58	1,426·8	±146·5

The incidence of Jassids at Galole is very low, the most troublesome pest being the American Bollworm to which I.C.58 shows more resistance than U.K.51 or U.K.58.

CULTURAL TRIALS

At Galole, three planting dates were compared using I.C.58. The plot size was 39 ft. by 42 ft. with a spacing of 3 ft. by 1½ ft.

TABLE VI—MEAN YIELD OF SEED COTTON IN LB./ACRE

	Planting Dates		
	11th April	20th April	9th May
	1,674·9	1,099·3	975·0
L.S.D.	5%	1%	0·1%
	223·4	315·3	450·4

The increase in yield of the early planted cotton over the cotton planted subsequently, was highly significant (P=0·001). There was no significant difference between the yields from the two latter planting dates.

Perkerra Experimental Station (3,300 ft.)

CROP EXPERIMENTS

These were mostly concerned with horticultural crops and following the success of the first crop of Bombay Red onions on tenants' holdings, experimental work on this was stepped up. The immediate problems to be investigated with onions are its watering and fertilizer requirements, whether they are best planted by seedlings or by sets, control of nut grass and thrips, whether the crop will grow as well on the heavy soil areas as it does on the medium-textured soil, and the best techniques of harvesting and curing to avoid excessive damage during transit.

Work continued on chillies, bananas, citrus, dates and short season maize. Some new varieties of dates were obtained from the Sudan and added to the existing collection of Californian varieties. Considerable interest was shown in this date collection.

Beef Production

The beef experiment which started in 1959 will be completed early in 1961 when the last animals go for slaughter. The object is to compare three different breeds and two methods of feeding, namely grazing on irrigated Star grass versus stall feeding on Napier grass, also grown under irrigation. The three breeds were Hereford half breds, Sahiwal half breds and local natives. The Sahiwals and natives on arrival in 1959 were in poor condition and gained weight rapidly at the start, then slowed down, whereas the Herefords gained weight steadily throughout the two years. The mean overall liveweight gains per day up to the end of 1960 were: Herefords 0·80 lb., Sahiwals 0·65 lb., natives 0·65 lb. Some observations made on the behaviour of the various breeds are of interest. The Sahiwals were reluctant to graze the Star grass closely and therefore they required a larger total area to support them than did the other two breeds. The Herefords and natives were supported at the rate of four beasts per acre of Star grass, the Sahiwals at four beasts to 1¼ acre. The Sahiwals appeared less heat tolerant than the Herefords and put on less weight during the dry season. On the other hand, the Sahiwals continued to gain weight during rainy weather whereas the Herefords slowed down at those times.

L. J. COLLINGS-WELLS,
Agricultural Research Officer.

ANNUAL REPORT OF THE OFFICER IN CHARGE OF AGRICULTURAL MACHINERY RESEARCH AND DEVELOPMENT, 1960

Sisal Drying

Roughly half the cost of machine drying of sisal is the cost of the heat required o evaporate the water. Three alternative sources of heat were investigated on a heoretical basis all being used in conjunction with a drier with an output of four tons lried sisal in eight hours operating at 180° F. with a heat input of 1,000,000 B.T.U./ lour.

Solar Energy

It was assumed that the drier would operate at constant temperature, the air irst being heated directly in a flat plate solar collector, and then brought up to the required temperature by an oil fired heater. With solar radiation of 1,600 B.T.U.s per sq. ft. per eight-hour day (average Kabete 1938–42 = 1,700 B.T.U.) curves were drawn of heat collected against collector area for three efficiencies of collector with a constant airflow of 38,400 lb. per hour. From these curves the annual drying (fuel) costs were calculated by adding the cost of supplementary fuel oil at Sh. 7/68 per million B.T.U. to the annual cost of the collector. The annual cost of collector was found by dividing the initial cost of collector by its expected life, and adding an annual charge for cleaning and maintenance.

Table I shows the estimated annual heat costs using collectors with overall coefficients of heat transfer between the air inside the collector and the outside air of 2, 2·5 and 3 B.T.U. per sq. ft. per hour per degree F. with annual costs of Sh. 1 or Sh. 2 per sq. ft. per annum.

TABLE I

Coefficient of Heat Transfer B.T.U. per sq. ft./deg. F./hr.	Annual Cost Sh. 1 per sq. ft.			Annual Cost Sh. 2 per sq. ft.		
	2	2·5	3	2	2·5	3
Collector area (sq. ft.)—						
0	19,086	19,086	19,086	19,086	19,086	19,086
1,000	16,615	16,960	17,310	17,615	17,960	18,310
2,000	15,006	15,360	15,710	17,006	17,360	17,710
3,000	13,926	14,280	14,970	16,926	17,280	17,970
4,000	13,018	13,890	14,760	17,018	17,890	18,760
5,000	12,457	13,510	14,890	17,457	18,510	19,890
6,000	12,224	13,980	15,200	18,244	19,980	—
7,000	12,550	14,460	15,850	19,550	21,460	—
8,000	12,859	14,490	16,510	20,859	—	—

Methane Gas

Unless digester could be constructed in something cheaper than reinforced concrete the costs would be similar to fuel oil at present prices.

Waste Heat from Turbines

The power required to operate a sisal decorticator and ancillary equipment is such that a turbine operating at 16 per cent efficiency, with a heat exchanger recovering 65 per cent of the waste heat, would supply sufficient steam to operate a drier to cope with the sisal produced. Burning distillate fuel the fuel costs would be the same as operating the factory on mains electricity and burning furnace oil in the drier. By running the turbines on methane gas, the fuel costs would be halved, but capital outlay would be very high.

Coffee Drying

(1) De-watering

Trials were made with two types of screen to shake water off parchment coffee straight from the washing channel. The first machine was designed as a jog trough conveyor with a screen 6 ft. by 3 ft. This was tried with a full range of throws, angles and speeds, and visual estimates of its effectiveness made. It could be set to produce parchment that when loaded onto a coffee tray would not release any more water by knocking the tray on the ground, but it was decided to abandon the rather costly and clumsy jog trough in favour of a vibrating screen using a rotary (eccentric) type of vibrator.

An experimental vibrating screen 48 in. by 16 in. was made using an A–B Vibro-Verken E.R.11 electric vibrator. This screen had a capacity up to 2,000 lb. wet parchment per hour, drying it to the stage where no more water could be shaken off. This screen was designed primarily as a feeder for the cascade drier.

(2) Cascade Drier

The information obtained from the 1959 drier was used to design a drier of riveted aluminium using removable perforated aluminium screens. The parchment was fed in at the top of the drier by a vibrating screen, having been pumped to the screen with water by a centrifugal coffee pump. The first section of the drier was a vertical chimney, the airflow being so adjusted that it would not quite lift good coffee, but would carry off hulls, platelets and any surplus water.

From the chimney the coffee fell onto the top tray which had a fall of 12 in. over 4 ft. the next tray fell 9 in. and the eight subsequent trays $6\frac{1}{2}$ in. each. This drier worked reasonably well with hot air at 120° F. giving an output of $\frac{1}{4}$ ton hulled coffee per hour. This was half the expected value due to (1) the perforated screens not allowing the expected airflow, (2) the coffee not moving over the screens fast enough, and the coffee being considerably more than skin dried.

The drier was then modified, the perforated aluminium screens being replaced by flattened expanded mild steel, riveted in place. The slopes were altered to the following (all slopes inches fall over a 4 ft. screen). (1) 15 in., (2) 11 in., (3) and (4) 9 in., (5) and (6) 8 in., (7) 7 in., (8) 8 in. In this form the drier had an output equivalent to 400 lb. dry hulled coffee per hour using air at 75° F. 60 per cent R.H. at the rate of 7,500 C.F.M.

Publications

"The Machine Drying of Sisal Fibre"—Kenya Sisal Board Bulletin, July and October, 1960.

I. M. JOHNSON,
Agricultural Research Officer (*Engineering*).

ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, CENTRAL PROVINCE, 1960

Rainfall at Experimental Stations, 1960

	Embu		Mulinduko		Kanja	
		days		*days*		*days*
anuary	0·02	(1)	1·10	(1)	Nil	
ebruary	0·24	(2)	0·22	(3)	1·18	(2)
Iarch	5·78	(10)	7·61	(11)	5·16	(12)
pril	6·60	(16)	6·63	(17)	8·71	(22)
Iay	2·16	(10)	0·97	(4)	4·28	(7)
une	0·82	(5)	Nil		2·73	(8)
uly	0·51	(5)	0·14	(1)	1·14	(12)
ugust	0·57	(9)	Nil		1·87	(13)
eptember	0·22	(2)	Nil		0·17	(6)
ctober	9·79	(10)	4·92	(8)	8·14	(18)
ovember	2·31	(8)	1·76	(5)	5·57	(15)
ecember	1·81	(7)	2·24	(8)	1·82	(7)
Total	30·83		25·59		40·74	
959	44·33		34·50		36·56	

Rainfall at all stations was about 10 inches lower than average for the whole year, he majority of the loss being accounted for in the very poor long rains period. Only by pursuing a policy of early planting, before the rains broke, was it possible to achieve a reasonable harvest this year.

Reports on Experiments

1. High Bracken Zone

Fertilizer and Farmyard Manure Trials on Arable Crops

The 2^4 trial to test Sulphate of Ammonia, Double superphosphate, F.Y.M. and Lime which has been quoted first in this report since 1956 was sown directly to Rongai Rhodes grass in the Long Rains of 1960, due to circumstances beyond our control he farm had to be handed back to the owners before the ley was in fit condition for ample cuts to be taken.

The second 2^5 manurial trial on arable crops was planted to maize in the Long Rains and the following treatments were tested: Double superphosphate reapplied at $1\frac{1}{2}$ cwt. per acre, Sulphate of Ammonia reapplied at $1\frac{1}{2}$ cwt. per acre, residual effect of 15 tons farmyard manure per acre (first applied in 1959), residual effect of Double Supers at $1\frac{1}{2}$ cwt. per acre (applied in 1959), and the residual effect of 6·6 tons Lime per acre (first applied in 1956 to molasses grass), all versus the nil application.

Treatment and yield figures are given below.

Yields in Lb. per Acre Dry Maize Grain

Treatment	With	Without	Response
Reapplied phosphate	2,348·1	2,083·9	+264·2
Residual F.Y.M.	2,372·3	2,059·7	+312·6
Residual lime	2,343·4	2,088·5	+254·9
Reapplied sulphate of ammonia	2,326·1	2,105·8	+220·3
Residual phosphate	2,440·3	1,991·7	+448·6

Yield of control plot = 1,254·8 lb. per acre.

Mean yield of trial = 2,215·9 lb. per acre. C. of V. = 9·4 per cent.

Significant responses p at 0·05 = 158·8 lb. per acre.
p at 0·01 = 221·4 lb. per acre.

The responses to reapplied phosphate, residual phosphate, residual F.Y.M. and residual lime all achieve significance at the 1 per cent level. Phosphate and F.Y.M. responses on arable crops were already well known at Kanja but the continued response to lime is of importance. In this particular trial the lime was originally applied to a molasses grass ley in 1956, in previous trials where lime has been applied to the arable crop at the beginning of a rotation responses have been most erratic and often negligible.

A trial to test the residual effects of three rates each of double superphosphate, agricultural lime and farmyard manure was undersown to Rongai Rhodes grass in 1959, sample autoscythe cuts were taken from this trial in 1960 in order to assess fertilizer and manurial effects. The cuts were taken when the majority of the trial area had reached the mid-flowering stage. Yield figures are given below and are expressed as tons of fresh green material per acre (bracken and weeds were removed before weighing).

Treatment	With	Without	Response
1 cwt. supers residual (from 1958) ..	7·95	7·74	+0·21
2 cwt. supers residual (from 1958) ..	9·21		+1·47
3 tons lime residual (from 1956) ..	8·87	6·78	+2·09
6 tons lime residual (from 1956) ..	9·25		+2·47
5 tons FYM residual (from 1958) ..	9·00	7·58	+1·42
10 tons FYM residual (from 1958) ..	8·32		+0·74

Yield of control plot = 5·73 tons/acre.
Mean yield of trial = 8·30 tons/acre. C. of V. = 18·4 per cent.
Significant responses p at 0·05 = 1·05 tons/acre.
p at 0·01 = 1·43 tons/acre.

The response by the grass to lime applied four years ago was outstanding in this experiment. Although the current price of lime makes its use of academic value at present the fact remains that a better take of grass is obtained when it is used. The effect of double superphosphate on the resultant ley is also noteworthy and confirms other work in the Bracken Zone that has indicated the beneficial effect of phosphate and lime on grass establishment.

Phosphate and Farmyard Manure Composting Experiment

In view of the consistent and quite large responses by arable crops to phosphate at Kanja it became of interest to find out whether a less expensive form of phosphate than double supers could be used with advantage. Uganda rock phosphate was selected for testing and due to its slow availability properties it was suggested that it should be tested after a period of composting with farmyard manure in the cattle boma. The composting process was allowed to go on for three months before planting the trial to English potatoes.

Treatments and yield figures (in bags of 180 lb.) are given below.

Treatment	Bags (180 lb.) per acre
5 tons F.Y.M. + 150 lb. double supers/acre applied separately in field	71·34
300 lb. double supers per acre	63·78
5 tons F.Y.M. + 150 lb. double supers/acre previously composted together	57·23
5 tons F.Y.M. + 300 lb. U.R.P. per acre previously composted together	54·20
5 tons F.Y.M. alone	53·19
150 lb. double supers alone	48·40
Control (no manure or phosphate)	35·80
Mean	54·85

Coefficient of Variation = 18·2 per cent.
L.S.D. between two treatments p at 0·05 = 17·90 bags/acre.
p at 0·01 = 24·96 bags/acre.

The application of 5 tons F.Y.M./acre plus 150 lb. double supers/acre applied normally in the field and not composted has outyielded the last three treatments listed at the 5 per cent level. The standard error of this experiment (Randomized blocks) was high due possibly to the erratic presence of bacterial wilt disease on some plots.

Fertilizer and Manurial Trial on Established Kikuyu Grass (Pennisetum clandestinum)

Reapplications of double supers and calcium ammonium nitrate were made on this experiment in the Gathano, the mulch treatment was disregarded and those previously mulched plots were ripped with a spring tine harrow. Before it was possible or practical to take sample cuts the farm was lost to us, but from visual observation it was very evident that both the reapplied fertilizer treatments especially when applied to previously ripped plots had a markedly beneficial effect. Perhaps this was due to improved aeration, allowing the grass roots to make better use of the fertilizer than had previously been the case under a dense grass mat. The ripping treatment also seemed to encourage indigenous clover growth in some cases. It was not possible by eye to detect any particular residual lime response but yield responses to this treatment have been erratic on Kikuyu grass.

2. Star Grass and Lower Kikuyu Grass Zone

Farmyard Manure, Phosphate and Nitrogen Rates Trial

This 3^3 factorial rates trial in 2 replicates was first reported on in 1959. In the Long Rains of 1960 the crop was Muratha-type maize planted bfeore the rains broke at a spacing of 3 ft. by 1 ft. The maize looked well throughout its growth. Only the sulphate of ammonia treatments were reapplied, namely 1 cwt./acre and 2 cwt./acre when the maize was $1\frac{1}{2}$ ft. high; the phosphate and farmyard manure treatments were not reapplied but residual effects were tested. Treatments and yields in pounds per acre dry maize grain are given below.

Treatment	With	Without	Response
1 cwt. s./ammonia per acre reapplied ..	3,305·10	3,064·22	+240·88
2 cwt. s./ammonia per acre reapplied ..	3,215·46		+151·24
1 cwt. double supers/acre residual ..	3,391·93	2,534·84	+857·09
2 cwt. double supers/acre residual ..	3,658·02		+1,123·18
6 tons F.Y.M./acre residual	3,078·22	3,209·87	−131·65
12 tons F.Y.M./acre residual	3,296·70		+86·83

Yield of control plot=1,840·20 lb./acre.

Mean yield of trial=3,296·70 lb./acre. C. of V.=17·7 per cent.

Significant responses p at 0·05=390·67 lb./acre.
p at 0·01=531·00 lb./acre.

Both rates of residual phosphate, originally applied in the 1959 Long Rains to potatoes, achieved significance at the 1 per cent level. There were no significant differences between levels of reapplied sulphate of ammonia or residual farmyard manure. The lack of response to F.Y.M. left by the potato crop is unusual on this farm. The response to residual phosphate is highly economic.

Farmyard Manure and Nitrogen Trial

In the same field as the above trial there is a 4×4 factorial experiment to test four rates of sulphate of ammonia and four rates of farmyard manure. The test crop was Muratha-type maize at a spacing of 3 ft. by 1 ft. sulphate of ammonia only was re-applied at 0, $\frac{1}{2}$, 1 and 2 cwt. per acre when the maize was $1\frac{1}{2}$ ft. high. The 1959 farmyard manure dressings were tested for their residual effects.

Treatments and yields in pounds per acre dry grain are given below.

Treatment	With	Without	Response lb. grain/acre
½ cwt./acre s./ammonia	3,412·20	2,982·41	+429·79
1 cwt./acre s./ammonia	3,006·61		+24·20
2 cwt./acre s./ammonia	3,400·10		+417·69
4 tons F.Y.M./acre (residual)	3,212·31	3,139·71	+72·60
8 tons F.Y.M./acre (residual)	3,248·61		+108·90
12 tons F.Y.M./acre (residual)	3,200·21		+60·50

Yield of control plot=2,710·40 lb./acre.
Mean yield of trial=3,200·21 lb./acre. C. of V. 17·2 per cent.
Significant responses p at 0·05=595·32 lb./acre.
p at 0·01=830·06 lb./acre.

There were no significant responses to reapplied sulphate of ammonia or to the residual effect of farmyard manure left from the 1959 potato crop which confirms the conclusion drawn from the first reported trial. There were no interactions between nitrogen and manure which approached significance.

The mean yield for the trial is quite high for this type of maize in Embu and it is possible that much of this is due to the experiment being dry planted a few days before the onset of the Long Rains.

Forms of Phosphate Trial

A new trial was started in 1960 to test various forms of phosphate with the object of finding out whether or not other and perhaps less expensive forms of phosphatic fertilizer would be as effective as double superphosphate on arable crops. There were 10 treatments randomized over 15 balanced incomplete blocks, each block consisting of four plots. The single plot size was 1/40th acre. The crop was unchitted Kerrs Pink potatoes.

As a basal dressing over the whole experimental area 10 tons farmyard manure per acre was applied, ridges were split over the manure at planting time.

Treatment and yield figures are listed below, yields are in bags (180 lb.) of tubers.

Treatment	Yield (180 lb. bags)
Control—no phosphates	45·64
1½ cwt. double supers/acre	45·91
3 cwt. double supers/acre	47·39
6 cwt. soda phosphate/acre	45·61
6 cwt. fused magnesium phosphate/acre	45·31
6 cwt. basic slag/acre	41·51
8 cwt. hyperphosphate/acre	43·76
8 cwt. Seychelles guano/acre	42·92
8 cwt. Tanganyika rock phosphate (unground)	41·00
8 cwt. Tanganyika rock phosphate (ground)	48·23
Mean	44·72 bags/acre

Least significant difference between two treatments—p at 0·05=7·36 bags/acre.

There were no significant differences between any of the various phosphate treatments. As the yield of the control plot is higher than the mean of the trial it is assumed that the crop obtained the nutriments that it required from the basal farmyard manure. Yields were low due to lack of rainfall at the most vital times and to the ravages of potato tuber moth. There was no blight attack.

Coffee Variety Trial

This experiment to test five varieties of Arabica coffee in a Latin square design with nine trees per plot has now reached its 3rd cycle. Before the two old bearing stems were removed a small crop was taken from them from June until November. Yield figures were measured on cherry weight and then converted to weights of clean coffee by a 6:1 ratio. Varieties and yield figures are given below.

Variety	*Cwt. clean coffee per acre*
S.L.14	4·76
S.L.28	4·54
N.197	4·29
S.L.34	3·45
Kents	3·14
Mean	4·04

Least significant differences p at 0·05 = 1·82
p at 0·01 = 2·56

There are no significant yield differences between the varieties. S.L.14 once again comes at the top of the list possibly due to its drought-resistant properties although this variety has been noted to be very prone to rust infection.

Two further coffee trials namely (1) Method of mulching and anti-leaf fall spray trial and (2) The manurial drop-out trial will be reported separately by the Coffee Research Station.

Tea Trials, Kagochi, Nyeri District

Since the 1959 report no new trials have been undertaken. The majority of these experiments are of very long duration and it would serve no useful purpose to report interim results for these. The 2^5 fertilizer trial is however of interest in that it is conforming to the general pattern of fertilizer response for young tea, it is apparent that potash is effective in the early stages and that nitrogen (as Urea in this case) may be of advantage subsequently.

District Fertilizer Trials

These are the subject of a separate report by the Soil Chemist.

Grass Woodland Zone—Mulinduko Farm

Farmyard Manure, Phosphate and Nitrogen Trial

A new trial was started in the Long Rains to test three rates each of F.Y.M., double superphosphate and sulphate of ammonia, the design was a 3^3 factorial in one replicate. The experiment had to be laid down in three blocks of 9 plots each in order to avoid the many anthills which are a prominent feature of this zone. The first test crop was English potatoes.

Treatments and yields are given below in bags (180 lb.) per acre.

Treatment	With	Without	Response
1½ cwt. s. ammonia/acre	18·86	18·97	−0·11
3 cwt. s. ammonia/acre	24·76		+5·79
1½ cwt. double supers/acre	22·48	16·65	+5·83
3 cwt. double supers/acre	23·45		+6·80
11 tons F.Y.M./acre	21·62	17·51	+4·11
22 tons F.Y.M./acre	23·45		+5·94

Yield of control plot=9·41 bags/acre.

Mean yield of trial=20·86 bags/acre. C. of V. 15·9 per cent.

Significant responses p at 0·05=3·25 bags/acre.
p at 0·01=4·49 bags/acre.

Responses to all fertilizers achieved significance at the 1 per cent level with the exception of the smaller sulphate of ammonia dressing. The interaction between the middle rates of phosphate and farmyard manure was significant at 5 per cent. The level of yield on this trial was low, mainly due to low poorly distributed rainfall and the fact that the seed was not chitted.

Groundnut varietal observation plots were replanted in the Long Rains and four varieties were outstanding. Single plot sizes were small at 1/90·75 acres. The varieties of greatest interest were:—

	Yield shelled nuts per acre
U/A−19=B.727	2,087
U/A−20=B.728	2,087
U/A−24=B.735	2,178
S/A−2=Barberton Bunch ..	1,996

These varieties will be bulked in larger plots in 1961 when a more true yield picture should result. No rosette disease was seen on these varieties all of which are "bunch" types. The spacing used was 1 ft. by 6 in. and 1 cwt./acre double superphosphate was applied along the rows at planting time.

A 2^4 Banana culture trial to test pit planting versus flat planting, phosphate application, mulch application, and "pruning" is as yet in its early stages but it is becoming obvious that pit planting pays off in an area of limiting rainfall. It is not yet possible to assess the effects of other treatments.

Yields from the small Napier spacing trial were very low indeed due to lack of rainfall. Over three cuts the 12 ft. spacing treatment gave only 13·55 tons per acre green herbage, the 4 ft. and 8 ft. spacings were both lower than this.

M. E. H. VICKERS,
Agricultural Research Officer.

ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, RIFT VALLEY PROVINCE, 1960

Weather Conditions

Monthly rainfall totals at Experimental Stations are shown in the table below, n inches.

	Kitale	Eldoret	Ol Joro Orok	Nakuru	South Kinangop	Perkerra
January ..	0·10	0·04	0·64	0·17	1·80	—
February ..	2·72	0·36	0·20	0·96	4·26	0·21
March ..	7·11	5·53	3·69	3·05	5·34	1·38
April ..	3·34	1·71	3·34	3·30	8·28	1·50
May ..	3·16	5·43	5·87	4·37	4·10	2·11
June ..	4·25	0·94	2·68	1·14	1·32	0·24
July ..	5·15	4·84	4·97	1·59	0·52	2·71
August ..	5·88	8·43	9·10	7·04	1·93	2·58
September..	4·50	3·22	2·73	2·99	4·47	1·34
October ..	1·97	0·52	2·04	2·91	2·59	0·71
November..	1·35	2·08	2·02	2·11	4·38	0·93
December..	1·53	1·87	1·51	0·80	1·08	0·07
Total ..	41·06	34·97	38·79	30·42	40·07	13·78

The rainfall for the year was below average at most Stations, but in spite of this the majority of the experiments came through well. Nakuru district however suffered more severely from drought conditions and were forced to abandon or postpone several of their experiments. In the African areas some of the fertilizer trials were adversely affected by dry conditions but most of them were successfully harvested.

Kitale Experimental Station (6,200 ft.)

Maize Experiments

This work continued on an increased scale during the year, in view of the importance of the crop in the Trans Nzoia District.

An experiment to compare various forms of phosphatic fertilizer on maize did not show any significant difference between them but suggested that Japanese fused magnesium phosphate may be useful, depending on its price.

In a fertilizer rates and spacing experiment on maize which has now run for three years at Kitale and Cherangani and for two years at Endebess, the optimum combination appears to be the higher rate of sulphate of ammonia (2 cwt./acre), the middle rate of triple superphosphate (75 lb./acre) and a maize plant population of 10,000 to 14,000 plants per acre. The response to sulphate of ammonia in the last two years has been strongly linear so it will probably now be worth testing higher rates.

Other fertilizer experiments on maize consisted of a comparison of various compound fertilizers against "straight" fertilizers, and an experiment to test the effect of applying magnesium and gypsum.

Two cultivation trials were done on maize. In the first, wide spaced (7 ft. by 2 ft.) maize was interplanted with various other crops to improve the forage value of the stover after harvest and to determine whether the maize yield suffered any depression. The latter was reduced from 21·2 bags per acre to 18·7 bags as a result of the wide spacing and further reduced to 15·5 bags when Rhodes grass was interplanted. This however produced an excellent stand of grass, but its value in relation to the reduced yield of maize was not worked out. Velvet beans was the best of the interplanted legumes, but reduced the maize yield to 18 bags per acre.

The other maize cultivation trial was to test the effect of subsoiling at 3 ft. intervals at 16 inches depth. For the second successive year this treatment did not improve maize yields.

Alternative Crops

Trials were continued in an attempt to find crops which could reduce the economic dependence on maize by farmers in the Trans Nzoia. These trials included variety and fertilizer investigations on sunflower, soya bean, niger oil and gram. In addition, a number of potential fodder crops were tested in observation plots. Of these, kale appeared the most promising, giving a yield of up to 23 tons per acre of fresh material.

Calf Feeding

The 1959 experiment on Jersey calves was repeated in 1960. While the results are not yet available it is expected that they will confirm those of 1959 which were that:—

(*a*) The small benefit from feeding concentrates to a calf which is still receiving skim-milk is highly uneconomic under the Kitale calf rearing régime.

(*b*) "Early weaning" depresses the growth curve during the early stages of life.

(*c*) With a butterfat market and consequent availability of skim-milk, the "early weaning" method is highly uneconomic.

Cow Feeding

An experiment was started to compare the milk production of Jersey cows on the following four treatments:—

(*a*) Grass only.

(*b*) Hay + concentrates, stall fed.

(*c*) Grazing and concentrates.

(*d*) Grazing only.

The experiment will continue for the full lactation of the eight cows on each treatment, so results are not yet available but one very interesting observation has been made. This is that the "steaming up" which was applied to all four treatments has had an enormous beneficial effect on milk yields compared with 1959 when no steaming up was done.

Pig Feeding

The main objective of this work at Kitale is to find out to what extent maize can be safely included in the rations of bacon pigs, and the best form of protein food to use with it. A trial done in 1960 to compare maize with barley as the cereal component and Pig Industry Board supplement versus skim-milk as the protein supplier was successfully completed but results are not yet available. A new trial has been started to compare three levels of maize in the ration, namely 74 per cent, 64 per cent and 54 per cent up to 120 lb. liveweight, then 80 per cent, 70 per cent and 60 per cent up to slaughter.

Eldoret Experimental Station (7,000 ft.)

Fertility Building Trial

This trial started in 1958 when a range of manurial and green manuring treatments were applied. These fertility building treatments were reapplied in 1959 and a barley test crop grown in 1960 to test their effects. Barley yield differences were not significant but there was a strong indication that those treatments which had received farmyard manure or which had been grazed had given higher barley yields than those which had grown "straight" green manure crops. A second test crop will be grown in 1961.

Fertilizer Trials on Wheat and Maize

An experiment was done on wheat to compare three different forms of phosphatic fertilizer. These were triple superphosphate, Japanese magnesium phosphate and Tanganyika Minjingu rock phosphate. The results indicated that under conditions

of infertile soil at Eldoret Experimental Station Japanese magnesium phosphate if priced at 240–250 shillings per ton and Tanganyika Minjingu rock phosphate at 140–150 shillings per ton would be economically comparable to triple superphosphate at the current price of 695 shillings per ton.

Another experiment on maize was started in 1959 to compare the effect of three compound fertilizers against triple supers, each being applied at the same cash value per acre, namely the cost of 100 lb. per acre of triple supers (Sh. 32/70). The treatments were reapplied in 1960. In both years triple supers gave the highest yield and was the only fertilizer which more than paid for itself. The compound fertilizers were:—

(*a*) 10.20.10.4; (*b*) 10.30.0; (*c*) Kenaf No. 2.

A similar experiment was started with wheat in 1960 but no significant differences were obtained.

Farmyard Manure

Various times of application of farmyard manure for maize were compared in an experiment started in 1960. The times were 31st January, 26th February, 21st March and 23rd March, the latter being a top dressing immediately after planting the maize, while the first three were ploughed in at once after spreading. The results have not yet been analysed but it appears that the later the application the greater the yield, although in this particular season the top dressing treatment probably had a beneficial mulching effect during the drought just after planting.

Another experiment was started in 1959 to compare various types of farmyard manure. In that year 10 tons per acre of pig manure gave a higher maize yield than the same dressing of either cattleyard manure or poultry yard manure and than 200 lb. per acre of triple supers. No reapplications were done in 1960 and wheat was grown to assess residual effects. The wheat on the pig manure plots lodged badly which resulted in a greatly reduced yield—10·29 bags per acre compared with 10·84 bags on the control plots and between 13 and 14 bags for each of the other three treatments—cattle yard manure, poultry yard manure and triple supers.

Pig-Feeding

An experiment was done to determine whether the Pig Industry Board protein and mineral concentrate could replace skim-milk in the baconer ration. The control ration consisting of barley, maize, minerals and skim-milk gave the best results for liveweight gain, conversion ratio and carcass grading. It was apparent however that the P.I.B. concentrate could be a useful protein supplement for a farmer who has no skim-milk available. It may also be particularly useful to farmers whose pigs are soft setting as it appears to be a good fat hardener. On the economic side it is calculated that when skim-milk is plentiful and cannot be sold for more than 26 cents per gallon this should be fed, but between 26 cents and 72 cents per gallon it can be partly replaced by P.I.B. concentrate while over 72 cents it is most profitable to replace it entirely by the latter.

Another experiment was to investigate heavy hog production at the request of a large United Kingdom firm. Three rations were compared, each being fed *ad lib.* The economic results of the experiment suggest that heavy hog production could be more profitable than the present production for Wiltshire bacon, in the case of farmers obtaining an average return of Sh. 227 to Sh. 230 or less per baconer.

Poultry Feeding

Two farm-mixed rations were compared for egg production by Rhode Island Red x Light Sussex hens. The results indicated that both these rations, although cheaper than the standard commercial ration on a weight basis, were more expensive when assessed in terms of eggs produced.

In another experiment the object was to test the effect on egg production of artificial extension of day length in batteries and in deep litter houses. Kerosene lamps were used from 6 p.m. to 9 p.m. each evening. Results were only obtained for the first 10 weeks but suggested a possible small increase in laying per cent due to artificial lighting, especially with the battery fed group. A more accurate experiment using electric light has been planned for 1961.

Ol Joro Orok Experimental Station (7,800 ft.)

Ley and Fodder Species

Numerous species and varieties of ley grasses and clovers were under trial in observation plots during the year. Among the most promising of these should be mentioned two strains of *Setaria sphacelata*, namely the improved Nandi strain and the Meru strain. Among the pasture legumes under trial one which was outstanding was *Trifolium subterraneum* var. Clare, while on vlei soil Yarloop variety of this species grew very well.

An observational trial compared three different silage crops, namely maize/peas, oats/vetch and oats alone. The oats/vetch mixture gave the highest yield of fresh material, 17·9 tons per acre but a crude protein content of only 2·6 per cent which however was higher than that of the other two crops. The stage of cutting is not known.

In a comparison of two varieties of kale, Marrow Stem yielded 27·8 tons of fresh material per acre compared with Chou Mollier which gave 14·9 tons.

Fertility Building on Vlei Soil

An observational trial was laid down on 50 ft. camber beds to test numerous plants for either green manuring or grazing by sheep as methods of building up fertility on this soil. Grazed crops and grasses were, in order of yields of fresh material: oats/peas (19·4 tons), oats/vetch (18·3 tons), Yarloop clover (4 tons), H.I. Ryegrass (4 tons), purple vetch (1 ton). Two of the grasses, Timothy and Meadow Fescue failed due to slow initial growth in competition with weeds. Sweet blue lupin as green manure produced 18 tons per acre for ploughing in.

Chisel Plough Trials

Comparative trials were carried out on three farms in the Mweiga (two sites), Ol Joro Orok and Rumuruti areas respectively, to test the effect of chisel ploughing with or without fertilizing and seeding, as a means of improving natural grassland. At the Ol Joro Orok site chisel ploughing and fertilizing have caused a marked improvement which will be assessed by cuts in 1961. The effect has been less at the other sites which however suffered from drier weather. Further work is planned for 1961.

Alternative Crops

Six sunflower varieties were planted in July and although not yet harvested growth has been excellent. Five of the six varieties were from the U.S.A. and one from Israel. Considerable variation has been noted between varieties as regards prickliness of the seed heads.

Eight varieties of root chicory were on trial and the highest yielder was one from the U.S.A. which produced 14·1 tons of roots per acre. As however the small requirement of chicory in East Africa is understood to be already fully satisfied, work on this crop will not continue for the time being.

Pig Feeding

An experiment was done to determine the optimum level of restriction needed in the feeding of a baconer ration consisting of cereals, with Pig Industry Board concentrate as the protein and mineral component. The cereal was barley with a small proportion of oats. Carcass evaluations were kindly done by the Animal Husbandry Division of E.A.A.F.R.O. Final results are not yet available but on the basis of killing out percentage, conversion ratio and setting quality of fat, it is concluded that "heavy" restriction of feeding of this ration is desirable both before and after 100 lb. liveweight.

Another experiment was started in October to compare three levels of oats replacing part of the barley in the baconer ration. The levels of oats were 15 per cent, 30 per cent and 60 per cent up to 100 lb. liveweight, changing thereafter to 15 per cent, 20 per cent and 30 per cent respectively. During the first three months of the trial the first two rations have given the same liveweight gain, but the rate on the third ration (highest level of oats) has been slower.

Sheep Experiments

In an experiment on fat lamb production, pure Corriedale lambs were compared with cross bred lambs, namely Corriedale x Hampshire Downs and Corriedale x Border Leicester. Two years' results are now available, from which the following conclusions have been drawn under Ol Joro Orok Experimental Station conditions. Pure Corriedale lambs may be best kept on for a wool clip at one year, then sold as Highland mutton. The Corriedale x Hampshire Downs produces excellent Highland lamb at 4½-5 months' old. The Corriedale x Border Leicester wether lambs can also produce a good return as Highland lamb but are less well finished. This cross may also be of interest for further crossing.

Studies were done on milk production of ewes of various breeds and crosses, assessed by a standard technique of weighing the lambs. These studies and others on respiration rate, etc., in relation to climate will be continuing in 1961.

Nakuru District

Copper Trials on Maize and Wheat

Copper sulphate was included in four trials in the Rongai area where a copper deficiency was suspected. Owing to drought all four trials were abandoned but it was observed that plots which had received copper sulphate did not succumb to drought until after the other plots. As a result of pot tests the Senior Soil Chemist has produced a map delineating the likely copper-responding area and it is hoped in 1961 to put down further field trials to check this.

Grasses for Drained Vlei

Four grasses were planted in mid-June on mole-drained vlei and on ridge and furrow-drained vlei. Yorkshire Fog (*Holcus lanatus*) has greatly outyielded the others, followed by Endebess Rhodes grass. The establishment of both Nandi *Setaria* and *Phalaris tuberosa* was poor. Growth on the mole-drained plots has been slightly better than on the ridge and furrow.

Potatoes

Potato variety trials were conducted at Mau Narok and Dundori. The latter trial was planted in October and has not yet been harvested. The Mau Narok trial contained 12 varieties. Marritta yielded 21½ tons per acre which was significantly higher than all other varieties. The level of yield was very high in spite of poor rainfall, due to the trial being sited on a field which had been heavily stocked by sheep for three years.

Three fertilizer trials were done on potatoes at Elburgon, Mau Narok and Dundori. The Dundori trial has not yet been harvested. At Elburgon 3 cwt. per acre of triple supers increased the yield from 7·28 tons per acre to 8·79 tons but 6 cwt. of this fertilizer produced no extra yield increase and there was no response to sulphate of ammonia. In the Mau Narok trial no significant fertilizer responses were obtained, unlike in 1959, probably because of the high fertility of the site of the trial, which had been a heavily stocked sheep pasture for three years.

South Kinangop District

Cultivation Trial

This long-term trial has now been running for five years. It is designed to find the best method of cultivating ridge and furrow land on the poorly drained Kinangop plateau grey soil, and also to determine the best method of straw disposal. The two sections of the trial are at different stages of the same rotation, which is four years arable followed by three years grass, the crop in each year of the arable being a cereal except for the third year when a vetch crop is taken for sheep grazing. The two cultivation treatments are ploughing versus rotavating and the three straw disposal treatments are burning versus ploughing-in versus carting off. The ploughing treatment is tending to maintain the shape of the ridges better than the rotavated treatment where the ridges are tending to sag slightly along the centres with consequent poorer growth of wheat.

L. J. COLLINGS-WELLS,
Agricultural Research Officer.

ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, NORTHERN DIVISION, NYANZA PROVINCE, 1960

Weather

Rainfall at Experimental Stations, 1960

The monthly totals from the Stations are given in the Appendix.

Apart from a few isolated places, rains have been more than adequate—too much in fact. Several trials have been washed out, including three on the Kano Plains.

There was very little break between Long and Short Rains at Kakamega.

Reports on Experiments

Exploratory Fertilizer Trials (Colony Programme)

Twenty of these were brought to harvest, the majority giving useful indications.

Results are being reported on by the Senior Soil Chemist.

Rates Trials (Colony Programme)

All four of these were harvested successfully and are being reported on by the Senior Soil Chemist.

In addition a 3^3 N P M trial with two replications was harvested at Kakamega on a red basalt loam and gave significant responses to all three fertilizers. Observations and weighed cuttings continue on the undersown Rhodes Grass.

Fodder Crops

Centrosema plumieri and *Dolichos argentus*

Both are growing successfully so far in combination with Napier Grass and Rhodes Grass at Busia; but it is too early to say, after only one cut, that they will continue to survive where so many legumes have already failed.

A fertilization of Napier Grass experiment, including F.Y.M., superphosphate and Belgian N.A.C. treatments, is being carried out at Busia, Shikusa, Kakamega, Lunyerere and Shitoli.

The F.Y.M. treatments appear generally to be the best at this stage.

Grassland

Establishment of a Grass Ley Underplanted to Beans

This experiment carried out at Busia with Rhodes grass and Molasses Grass and different rates of planting, showed that it was possible to obtain a satisfactory grass cover by undersowing to beans without a significant effect on the beans. A point of interest was the difference in behaviour of Rhodes grass and Molasses grass.

Mean Per Cent Grass Cover at Harvest

Rhodes grass alone	100
Rhodes grass sown after 1st weeding	95
Molasses grass sown after 1st weeding	88·3
Molasses grass sown after 2nd weeding	88·3
Molasses grass alone	76·7
Rhodes grass sown after 2nd weeding	53·3
L.S.D. 5%	18·22
1%	24·66
0·1%	32·95

Molasses grass appears to establish better under a cover crop and does not bject to being sown when the cover crop is already fairly dense.

Rhodes grass however is very sensitive to overshading and the "take" falls off apidly with delay in undersowing.

ESTABLISHMENT OF A GRASS LEY UNDERPLANTED TO MAIZE

This experiment was carried out at Kakamega with Stargrass and Rhodes Grass nd under four fertilizer régimes including combinations of P and F.Y.M.

Overall there was no diminution in yield of maize due to undersowing Rhodes Grass or underplanting Stargrass, but the interactions had a differential effect on he maize yield as under.

FIVE PLOT TOTALS IN LBS.

Main Treatment	1	3	5	Total
1)	131·79	137·40	101·01	370·20
P	151·06	134·30	141·02	426·38
M	151·25	141·11	183·11	475·47
PM	178·88	137·42	181·71	498·01
TOTAL ..	612·98	550·23	606·85	1770·06

1 = Maize u/s to R.G.
2 = R.G. alone.
3 = Maize u/p to Stargrass.
4 = Stargrass splits alone.
5 = Maize alone.

Hence maize undersown with Rhodes grass responds in the expected manner to ertilizers.

Maize underplanted to Stargrass does not respond to fertilizer at all.

In the absence of fertilizer it appears to be beneficial to the maize to undersow or underplant it to grass of either kind, but in the presence of Stargrass the fertilizer s wasted.

Apart from this it was confirmed that either grass sown or planted alone gave a etter cover than when undersown. (c.f. Molasses grass in the preceding experiment.)

EFFECT ON SUBSEQUENT CROP YIELDS OF CONTINUOUS CULTIVATION COMPARED WITH A GRASS/ARABLE ROTATION AS A MEANS OF EVALUATING THE LEY

The comparison being carried out, under a range of Phosphate and F.Y.M. reatments, takes the form of a randomized block with two replicates and is repeated at Kakamega, Bukura, Shikusa and Busia.

As both rotations started with the same crops, the experiment is concerned at present with fertilizers only and has each treatment duplicated within each block.

The Bukura experiment has failed for the third year running and has now been abandoned.

All replicates were under maize.

There were no significant fertilizer responses at Busia, although yields were high.

At Kakamega there were no significant responses, but there was a sizeable phosphate response at Shikusa. This was also significant on the combined analysis of the Kakamega and Shikusa trials which were on the same soil type.

Grass established well in the undersown plots at Busia and Shikusa, but failed at Kakamega, possibly owing to the very heavy maize crop. Direct reseeding will be needed here next long rains.

Testing of Five Ley Grasses for Persistence in the Face of Couch Competition Under Normal Grazing Management

This observational trial has been completed at Bukura. In order to have a fair comparison between seeded grasses (Nandi setaria, Endebess Rhodes and *Brachiaria ruziziensis*) and the Star and Pemba grass, the former were sown in nurseries and later planted as splits.

It was found that it was unrealistic to attempt to establish seedling grasses by splits as their "smothering" effect was lost. Under the low fertility conditions at Bukura, Stargrass ceased to be competitive and the *Brachiaria ruzizienisis* was useless and almost disappeared in competition with couch and other grass species. Pemba grass was fairly persistent in the face of couch competition.

Food Crops

Maize Trials

Trials have continued at Kakamega and in the Province and are being reported on by the Plant Breeder Kitale.

Cassava Variety Trial

This trial was carried out at Busia and Kakamega using 25 varieties in a Balanced Lattice Square design with three replicates. The trial at Busia was extremely well kept and yields were good; but the yields at Kakamega were much lower, although the order of varieties were much the same at both stations. On lifting, samples were taken for drying in order to obtain a conversion factor for each plot. Conversion factors varied so much from replicate to replicate on both stations, that no credence could be paid to them and yields were recorded as fresh weights.

Yields of Top Five Varieties

	Busia		Kakamega	
	Variety	*Yield tons/acre*	*Variety*	*Yield tons/acre*
	5025/30	16·34	50284/33 ..	5·69
	A. Valenca ..	11·59	50284/15 ..	5·32
	5025/28	11·54	5025/30	4·85
	50266/47	11·46	A. Valenca ..	4·37
	50583/14	11·25	50583/14 ..	4·04
L.S.D.	5%	2·742		1·79
	1%	3·716		2·42
	0·1%	4·975		3·25

Mosaic was reported as bad on the following varieties at Busia—50676/9, 50284/33, 50266/47, 50443/16 and 4747A/25. Varieties 50676/9, 46301/15, 50242/3, 5318/5, 4763/4, 4023/4 at Kakamega had previously been found with suspicious symptoms of Brown Streak but the same varieties were found to be free of the disease in this trial.

Further trials incorporating five varieties are to be carried out in 1961.

Trial of Blight Resistant Potatoes

Three varieties of potatoes were compared at two spacings at Kakamega in a Latin Square experiment.

Treatments	*Yields (tons/acre)*
K 52 at 9 in. in row	12·42
K 52 at 12 in. in row	11·48
Dutch Robijn at 9 in. in row ..	8·95
Dutch Robijn at 12 in. in row ..	8·61
C 53 at 12 in. in row	3·35
C 53 at 9 in. in row	3·03
Mean Yield	7·97
L.S.D. 5%	1·151
1%	1·570
0·1%	2·125

Conditions were extremely favourable throughout the season and no explanation can be seen for the comparative failure of C 53, which did so well at Kakamega in 1958. K 52 at the 9 in. spacing gave an increase of nearly 1 ton/acre over the 12 in. spacing; this was certainly economic but just missed significance at 5 per cent. The C 53 yields cannot be regarded as representative of Kakamega and therefore no conclusions can be made on the best spacing. Dutch Robijn showed no significant difference between spacings and therefore the wider spacing must still be regarded as the most economical.

Rice Planting Dates

This experiment at Busia, to find the best date for planting swamp rice in Elgon Nyanza conditions, has produced the same results as in 1959. Treatments were sited on irrigated bench terraces, so that water in each plot could be controlled to the same depth. Planting date was therefore the only variable. Rain was heavy in April (13·88 in.) and all plots were in standing water. The April plantings were drowned.

Treatments	*Mean Yield in lb./acre*
(1) Planted 8th February ..	3,529·16
(2) Planted 14th March ..	1,688·95
(3) Planted 14th April	Nil
Mean	1,739·37
L.S.D. 5%	1,566·24

The results were obvious—the earlier the planting date, the better the yields.

Sorghum Variety Trial

Five varieties of Sorghum, two white-grained and three red-grained types were compared in a 5 by 5 Latin Square at Busia.

Varieties	*Yield lb./acre*	
Dobbs White ex Kongwa	3,309	(18·38 bags)
S 344 Mabungoma	3,240	(18·00 bags)
S 752	3,240	(18·00 bags)
S 394 Egabara	2,482	(13·79 bags)
S 408 Imbudi	2,343	(13·02 bags)
Mean	2,923	(16·24 bags
L.S.D. 5%	759·6	(4·22 bags)
1%	1,065·0	(5·92 bags)

Dobbs White was heavily infected with covered smut at harvest. Smut heads were harvested separately and weighed. These weights were converted to clean head weights by proportion.

Black Food Beans (probably a variety of *P. vulgaris*)

The above dwarf field beans from Mbulu in Tanganyika were tested at Kakamega. No diseases apart from a little leaf spot were observed and the beans yielded five bags, equivalent to 1,063 lb./acre. Excellent growth was made.

Cash Crops

Groundnut Variety Trials

Two varieties of groundnuts, Asiriye Mwitunde and Homa Bay, were grown at two spacings in four observational blocks at Busia and tested for yield and incidence of Rosette disease.

The germination of both varieties was good but many plants in the closer spacing died out, especially in the Asiriye Mwitunde plots, leaving the ultimate spacings much the same for that variety, thus defeating the object of the experiment. Growth was poor throughout and yields poor.

Variety	Spacing	Yield Lb./Acre		
		Fresh	Dry	Shelled
Asiriye Mwitunde	2′ x 1′	1,530	1,021	587
Asiriye Mwitunde	2′ x 4″	809	592	484
Homa Bay	2′ x 4″	784	418	262
Homa Bay	2′ x 1′	358	214	165

The high mortality of Asiriye Mwitunde seedlings in the close spacing plots rendered the spacing comparison invalid, so very little new is learnt, for it was already known that Homa Bay was a lower-yielding variety than Asiriye Mwitunde.

Rosette was widely distributed but nowhere severe.

Variety	Spacing	Rosette Symptoms	
		Per cent Stunted	Per cent Not Stunted
Asiriye Mwitunde ..	2′ x 1′	1·23	8·51
Asiriye Mwitunde ..	2′ x 4″	1·11	9·15
Homa Bay	2′ x 4″	0·05	0·36
Homa Bay	2′ x 1′	0·95	6·55

Mortality was fairly high in the close spacing of Homa Bay, but the plant population was still twice as high as the wide spacing. The incidence of Rosette was much less in the close spacing and the yield was 20 per cent higher.

This conclusion however is suspect due to the universally low yields and poor growth.

Onion Variety Trial

Two varieties of onions, Bellary and Bombay Red were planted under four fertilizer régimes at Kakamega in observational blocks on 5th May. The seedlings were transplanted in June.

Rainfall was heavy and growth good, except for a short period when there was little sun and the weather was cold.

Yield Tabulation in Tons/Acre Fresh Onions

Treatment	Bellary	Bombay Red
5 tons F.Y.M.	6·81	6·08
5 tons F.Y.M. and 1½ cwt. triple superphosphate..	6·32	4·86
10 tons F.Y.M.	7·78	5·10
10 tons F.Y.M. and 1½ cwt. triple superphosphate..	8·26	6·81
Mean	7·29	5·71

Bellary appears to be the best variety for Kakamega.

The superphosphate appears to have no beneficial effect with the lower rate of F.Y.M., but there is a positive and beneficial interaction between superphosphate and the higher rate of F.Y.M.

Essential Oil Geranium

The observational blocks of essential oil Geranium—varieties Kenya and Bourbon—at Kakamega have been disappointing. The cuttings were planted in moist conditions on 11th May 1960 and the rains continued until October. Despite this only 1,060 Bourbon cuttings out of 6,000 and 89 Kenya cuttings out of 1,000 survived. The cuttings were consolidated into two blocks in the field and despite watering and mulching considerable losses again occurred.

The conclusion is that on a field scale one can expect 82 per cent mortality, even in sturdy cuttings of Bourbon, the more promising. This could possibly be corrected by closer planting and later thinning out. The outlook for this crop seems doubtful, especially in less-favoured areas under peasant conditions.

Sugar Cane Variety Trial. 25 Varieties R.S.D. Free. Plant Crop

This trial was harvested in August/September on the upper light soil at Kibos. Yields were good.

The first 10 varieties are seen below, first in order of cane yields and secondly in order of sucrose.

Yield of Cane			Yield of Sucrose		
Order	Variety	Tons/acre	Order	Variety	Tons/acre
1	Nco 293	114·68	1	Nco 293	11·751
2	Co 421	103·63	2	Co 421	9·015
3	Co 331	100·03	3	Co 617	8·870
4	Co 312	89·48	4	Co 602	8·535
5	Co 617	88·12	5	Co 331	7·972
6	Co 602	86·77	6	Co 312	7·889
7	Co 290	85·00	7	Nco 292	7·823
8	H38/2915	83·85	8	H38/2915	7·784
9	Co 453	82·67	9	Co 290	7·037
10	Nco 292	81·22	10	Co 411	6·788
L.S.D. at P 5%		16·66			1·562
1%		22·58			2·117
0%		30·28			2·834

Smut was serious and widespread in this trial, but varieties showed differential resistance. Scores for each variety in each of the three replicates were made. The Hawaiian varieties and some Co varieties were badly infected.

Variety	*Average per cent weight of infected canes*
Co 417	54
Co 453	31
H38/2915	24
H39/7028	47
H44/3092	33
B 4096	20
PR 1000	8
Co 360	9

Nco 293 seems a most promising cane. Co 421 free from R.S.D. has also done extremely well, and other old varieties free from the disease may give surprising results.

This trial is being carried on for the second ratoon in order to make smut observations. The trial would normally be abandoned and destroyed.

Six Nitrogenous Fertilizers on Ratooned Sugar Cane

The second ratoon was harvested at Miwani in May on sandy light soil. Variety of Cane was Co 421.

Yield Tabulation

Treatments	*Sucrose Weights Mean Yield in tons/acre*
Ammonium sulphate nitrate, 278 lb./acre	5·855
N.A.C., 3 cwt./acre	5·720
Urea I, 1 cwt./acre	5·506
Control	5·435
Urea II, 2 cwt./acre	5·349
Diammonium phosphate, 3 cwt./acre	5·290
Sulphate of ammonia, 3 cwt./acre	4·894
L.S.D. 5%	0·4315 tons/acre
1%	0·5811 tons/acre

Bad Land Improvement Trial

The first ratoon was harvested on heavy black clay at Miwani in May.

The main treatments were control, ripping in 4 ft. rips twice, gypsum application at 2 tons/acre, and a combination of the last two. These were then split for six sub-treatments which included green manure 4½ tons/acre ploughed in, filter press mud at 3 tons/acre ploughed in, trash at 1½ tons/acre ploughed in, an NPK fertilizer dressing (50 lb. N, 50 lb. P_2O_5, 50 lb. K_2O at planting and 50 lb. N as a top dressing) and a trash mulch of 1½ tons/acre.

In this first ratoon all effects of ripping and sub-treatments had been lost and only the main effect of gypsum was significant.

Main effect of Gypsum	*lb./acre*
Control	51647·68
Gypsum	88022·48
Mean	69835·08
Effect	36374·80
L.S.D. 5%	14013·23
1%	21228·88
0%	34125·41

The main effect of gypsum was significant at 0·1 per cent. This effect at 16·2 tons/acre or 70·4 per cent is undoubtedly more than economic, especially as there are indications that the gypsum effect may be almost permanent.

Rates and Frequencies of Application of Nitrogen Fertilizers on Sugar Cane

The plant crop of this experiment was harvested at Miwani on the light soils in January. Variety is Co 419.

Different rates and frequencies had no effect on sugar cane weights or sucrose weights, but results for sucrose per cent were significant.

Comparison of Treatments—Sucrose on a Scoring Basis

Treatments	*Score*
(1) 1 cwt. urea applied 4 times, 6 weeks intervals between applications	18·516
(2) 2 cwt. urea applied twice (6 weeks intervals)	18·083
(3) 1 cwt. urea applied twice as above	17·916
(4) ½ cwt. per acre urea applied once	17·905
(5) ½ cwt. per acre urea applied 4 times as above	17·873
(6) ½ cwt. per acre urea applied twice (6 weeks intervals)	17·794
(7) 2 cwt. applied once	17·761
(8) 1 cwt. urea applied once	17·699
(9) No Nitrogen fertilizer	17·639
(10) 2 cwt. urea applied 4 times	17·533
L.S.D. 5%	0·5116
1%	0·7008

The conclusion is that applying Nitrogen fertilizer increases the sucrose percentage so long as it is within the capacity of the plant to assimilate it, but that any Nitrogenous fertilizer in excess of that which can be readily assimilated is harmful.

Sugar Cane 25 Varieties Trial Under Irrigation

The second ratoon was harvested at Miwani in March. Rainfall was extremely good throughout the crop's life, so that irrigation was only needed on two occasions.

Harvested figures for the top ten varieties are shown below.

Cane Yields			Sucrose Yields		
Order	Variety	Yield tons/acre	Order	Variety	Yield tons/acre
1	Co 331	53·43	1	Co 408	5·052
2	Nco 310	51·30	2	Nco 310	4·984
3	B 41227	51·14	3	Co 331	4·938
4	B 41211	47·87	4	B 3215	4·934
5	Co 408	47·49	5	B 41211	4·837
6	B 3215	46·25	6	B 41227	4·751
7	PoJ 2961	43·85	7	PoJ 2725	4·541
8	PR 809	42·64	8	PR 809	4·330
9	B 37193	42·06	9	PoJ 2961	4·300
10	Co 419	39·97	10	B 3172	4·229
L.S.D. 5%		8·66			0·831
1%		11·74			1·126
0·1%		15·72			1·507

Mosaic was reported on two of the Barbados varieties B 41227 and B 37193.

The results of this trial, and the 25 variety R.S.D. unirrigated trial, prove the consistently good results obtained with Co 331 in this area.

J. R. GOLDSON,
Agricultural Research Officer.

TABLE I—RAINFALL AT SELECTED STATIONS (INCHES)

	Bukura	Kano	Busia	Kakamega	Kibos	Kisumu	Miwani
January ..	5·83	1·85	6·59	5·20	1·69	0·71	4·37
February ..	7·95	1·62	2·62	1·90	1·61	1·41	2·86
March	12·66	9·85	11·14	15·28	9·89	12·37	12·15
April	8·54	4·37	13·88	12·52	12·33	10·95	11·98
May	7·38	4·93	9·00	6·93	6·73	5·33	3·09
June	2·86	1·60	4·01	5·70	0·98	7·48	3·58
July	3·98	2·88	1·15	3·66	2·77	12·59	2·80
August	4·21	1·88	2·43	7·90	2·43	3·00	3·09
September ..	6·55	5·43	6·61	7·72	3·48	2·00	5·25
October ..	4·21	3·90	5·26	4·86	1·98	4·84	3·46
November ..	6·16	4·91	5·10	3·78	3·02	3·21	4·92
December ..	3·57	0·58	2·90	1·57	0·62	5·93	0·61
Totals ..	73·90	43·8	70·69	77·02	47·53	69·82	58·16

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General

TABLE I—RAINFALL (INCHES)

	Sotik	Kisii	Bomet	Kabosson	Homa Bay
January	6·05	2·78	4·68	3·66	3·06
February	3·64	2·26	3·13	4·86	6·97
March	8·49	4·00	10·18	8·55	7·31
April	7·28	9·34	10·73	4·19	7·32
May	2·84	6·92	1·38	1·95	5·59
June	1·43	4·11	2·30	0·67	3·71
July	2·73	1·82	1·08	1·22	3·85
August	5·02	3·81	1·39	5·59	2·89
September	4·92	9·91	3·14	2·59	8·33
October	3·88	4·62	4·36	1·02	3·34
November	3·92	5·83	2·67	1·94	3·25
December	1·62	2·46	1·84	2·21	1·14
Total	51·82	57·86	46·88	38·45	56·76
Average (years)	51·23 (7)	79·58 (?)	49·02 (4)	36·15 (3)	44·67 (10)

Generally the long rains began very early and finished early, again emphasizing the need for early planting. The end of the year was characterized by a particularly severe dry spell in all areas. Although rainfall was approximately normal for all areas except Kisii the distribution was poor with dry spells in May/June/July and again November/December.

Experimental Work

LEY SPECIES TRIAL

In the long rains of 1958 a trial was put down to test three grass species, namely Nandi Setaria, Nzoia Rhodes Grass and Star Grass, each with Kenya White Clover (*T. semipilosum*) and Louisiana White Clover (*T. repens*).

In addition each plot was split for superphosphate (42 per cent P_2O_5) at the rate of 150 lb. per acre versus nil on establishment.

In the long rains of 1959 the plots which had had phosphate on planting were top dressed at the same rate and all plots were again split for gypsum at 2 cwt. per acre as a top dressing. Overall dressings of nitrogen were given in November 1959 and August 1960 at rates of 2 cwt. of sulphate of ammonia per acre.

There have been differences between the grass species right through the trial and results for the three years are given in Table II in tons per acre of fresh matter.

TABLE II

Variety	1958–59	1959–60	1960–61
Nandi Setaria	15·17	19·67	13·81
Star Grass	9·14	12·20	13·91
Rhodes Grass (Nzoia)	13·01	10·83	9·56
Mean	12·44	14·23	12·43
Standard Error	±1·57	±1·42	±1·01
Coefficient of Variation	12·6%	10·0%	8·2%

Allowing for the fact that 1958/59 was the planting year and also that 1960/61 includes a very dry season it can still be said that the seeded grasses have fallen off in production from the first year. The seed of Nzoia Rhodes Grass was obtained by the kind permission of Buchanan's Kenya Estates Limited and was the same as their original planting which was still a useful paddock at the end of five years. Recent experience with commercial seed is that with the Rhodes grasses the longevity is far shorter.

After the first year both clovers decreased in production and by 1961 only odd patches can be seen. The clovers nodulated well after planting.

Phosphate made a great difference over the first two years, but the analysis of the third-year results shows little difference between phosphate and non-phosphate plots. Figures for phosphate are given in Table III in tons fresh matter per acre.

Table III

Year	−P	+P	Standard Error	Difference
1958–59	8·20	16·67	±0·79	+8·47
1959–60	10·76	17·71	±1·03	+6·95
1960–61	12·45	12·41	±0·93	−0·04
Total ..	31·41	46·79	—	+15·38

No significant differences have been shown for the gypsum application and it made little difference to the exodus of the clover.

Although the trial has not yet been completed it would be in order to make one or two observations. Firstly, in this area, if and when a seeding Star grass is produced, there is the basis for a long-term ley with the Rhodes forming the bulk early in the first year giving way to Setaria which finally would be succeeded in the main by Star grass. Secondly Nzoia Rhodes Grass is little use for a four-year ley and, even though Setaria produces well, it is still liable to fall off in production.

Effect of Gypsum and Superphosphate on Establishment and Growth of a Rhodes Grass and Kenya White Clover Ley

A trial was laid down in the long rains of 1960 to test the effect of gypsum on the establishment and growth of a new ley in the presence of different levels of phosphatic fertilizer. A poorish field was chosen for the site where soil analysis had indicated a low sulphur status.

The rates of gypsum were 0, 1½ and 3 cwt. per acre and these were combined factorially with superphosphate (42 per cent P_2O_5) at 0, 3 and 6 cwt. per acre.

Table IV gives results for the grazing to date in cwt. dry matter per acre.

Table IV

		Superphosphate Cwt./Acre			Mean
		0	3	6	
			±4·32		±2·49
	0	10·78	48·21	63·90	40·96
Gypsum	1½	10·92	51·58	71·93	44·81
Cwt./acre	3	16·26	54·95	84·08	51·76
			±2·49		
Mean		12·65	51·58	73·30	45·84

Coefficient of Variation=18·8 per cent.

There is an almost linear response to superphosphate up to the higher level.

Although there is a significant response to gypsum at the 3 cwt. level the advisability of using it in the seed-bed is not warranted. The sulphur can be put on in the form of a nitrogenous fertilizer such as sulphate of ammonia which will supply both sulphur and nitrogen. 3½ cwt./acre nitrogen in the form of calcium ammonium nitrate was given during the year.

Had this been put on as ammonium sulphate the amount of sulphur equivalent to the 3 cwt. of gypsum would have been applied.

The points of interest are the enormous increase obtained on these very phosphate-deficient soils and also the observation made that the Kenya White Clover was more in evidence on the non-phosphate plots than on the phosphate plots. This latter observation cannot be over-stressed and fits in with observations in Australia where it has been shown that some legumes are better extractors of elements from the soil than other species.

Fodder Grasses

The fodder grass trial laid down in 1959 was continued during 1960.

Results are given in Table V in tons fresh matter per acre for the complete year 1959–60 and for 1960–61 up to 31–12–60. The latter includes three cuts only.

Table V

Species \ Year	Year	
	1959–60	1960–61
Pennisetum purpureum	42·78	20·48
Setaria splendida	39·40	10·74
Panicum maximum	25·54	12·07
Ronpha grass	18·88	6·69
Tripsacum laxum	17·99	15·31
Panicum makarikariensis	15·69	11·92
Mean	26·71	12·87
Standard Error	±5·09	±2·65
Coefficient of Variation	19·1%	20·6%

Although the 1960–1961 figures are not complete, the improved showing of the Guatemala Grass (*Tripsacum laxum*) is evident as is the much poorer showing of *Setaria splendida*—the latter is probably due to the much drier conditions experienced since May 1960 and the drought conditions of December 1960, January 1961.

Weed Control in Ley Establishment

In previous years, although the use of phosphate in the seed-bed has clearly been necessary for successful ley establishment, it has increased the amount of weed in the sward in the early stages. The generally accepted method of weed control is mowing off the weed, but it was thought that if a weedicide could be used to control weed in the very early stages, i.e. before it was tall enough for mowing, the effect of the fertilizer on the sown species might be even more increased at the expense of the weed.

Accordingly a trial was laid down using Nandi Setaria and Kenya White Clover and the plots were dressed on seeding with 0, 2, 4 and 6 cwt. of superphosphate (42 per cent P_2O_5) per acre. These plots were then split for methods of weed control, which were mowing and the use of a weedicide (in this case DNBP and 2:4 D.B.).

The plots had to be mown three times before effective weed control was obtained, but the weedicide was relatively ineffective in spite of two sprayings and appeared to decrease the yield of grass and clover slightly.

Mowing did control the annual weed grasses such as *Eleusine coracana* and *Setaria verticillata* which increased on the sprayed plots.

The plots were cut and weighed and results up to the end of 1960 are given in Table VI in cwt. fresh matter per acre.

TABLE VI

	Superphosphate Cwt./Acre				Mean
	0	2	4	6	
		±3·48			±1·74
Spraying ..	28·40	38·90	36·65	37·15	35·28
Mowing ..	31·10	37·92	42·71	39·60	37·83
		±2·04			
Mean ..	29·75	38·41	39·68	38·38	36·56

Coefficient of Variation=21·3 per cent.

The field used for the trial was in far better "heart" and did not respond to phosphate so markedly as the trial on Rhodes Grass above. The 2 cwt. per acre appears to be the optimum and this is significantly better than the control (5 per cent level).

Comparison of Ley Grasses by Means of Milk Production

This trial was laid down in 1959 to compare the production of ley grasses in terms of gallons of milk per acre.

The four grasses were Nandi Setaria, Nzoia, Endebess and Rongai Rhodes Grasses. These were arranged in a Latin Square, and carefully chosen animals grazed each row of plots in successive weeks to complete a grazing cycle. The animals were completely confounded with the columns of the square.

The results for the first year are given in Table VII in terms of tons fresh matter per acre and gallons milk per acre. In all, five grazing cycles were completed during 1959–1960.

TABLE VII

Grass	Tons fresh matter/acre	Gallons per acre
Setaria	26·2	927·8
Rongai Rhodes	18·5	849·6
Endebess Rhodes	16·6	805·7
Nzoia Rhodes	14·6	811·9
Mean	19·0	848·8
Standard Error	±1·8	±72·9
Coefficient of Variation	9·5%	8·6%

The trial was continued into 1961, but the results for 1960–61 are not yet complete. It is expected that yields will be considerably lower in this, the second year of the trial.

The fourth grazing of the 1960–1961 year will be completed by the end of January 1961 but, after eight weeks with initially no rain, growth has been slow. The interesting fact, that has shown up very well during the dry weather, has been the almost text book response of the grasses to drought.

Whereas the Rongai Rhodes is still very green and producing well, the Setaria has been burned completely. The Endebess Rhodes, although not as good as Rongai, is far superior to the Nzoia Rhodes, which is little better than Setaria in its ability to combat really dry conditions.

Passion Fruit

A trial was laid down in 1959 on passion fruit, with a view to obtaining some information on controlling "woodiness disease". Three treatments were incorporated in the trial. Firstly it was decided to test whether a systemic insecticide could be used to keep out the disease, and also whether the nutrition of the plant increased susceptibility. The systemic insecticide was Metasystox sprayed every twenty-one days at a strength of 0·1 per cent. The dressing of manure and fertilizer was twelve tons of farmyard manure per acre, together with 2 cwt. per acre basic slag and 2 cwt. per acre superphosphate (42 per cent P_2O_5).

A further factor was incorporated, as it was desired to test whether seedlings raised in an insect-free environment were better than those to which possible vectors of "woodiness" disease had had access from the time the first shoot appeared. These are denoted by "clean" and "dirty" seedlings respectively.

Cropping began in May 1960 and the yields in lb. of fruit per acre are given in Table VIII.

Table VIII

	"Dirty" Seedlings	"Clean" Seedlings	D.S. + Fertilizer	C.S. + Fertilizer	Mean
		±2,067·8			±1,014·0
Not Sprayed	19,874·3	15,956·1	21,081·2	15,595·4	18,126·8
Sprayed	20,414·2	22,136·2	20,643·4	17,816·5	20,252·6
		±1,462·1			
Mean	20,144·3	19,046·2	20,862·3	16,706·0	19,189·7

Coefficient of Variation = 21·6 per cent.

None of the results from the treatments to date have reached significant levels, but a surprising result is the slight decrease due to fertilizer and manure. This may be different in the second year's crop.

Observations on the trials show that there is no systemic pattern of diseased plants, but that vines all over the trial are beginning to show symptoms and any increase due to spraying is not a result of "woodiness" control. The mean yield of 19,189·7 lb. per acre represents a return of Sh. 2,878/46 per acre for the first seven months of harvesting at the present price of Cents 15 per pound.

Geranium Oil Trial

Due to an increased interest in essential oils and a desire to know whether oil yields could be affected by fertilizer application, a nitrogen/phosphate trial on Bourbon geranium was laid down at Sotik in 1960.

The phosphate treatments were superphosphate (42 per cent P_2O_5) at 0, 2 and 4 cwt. per acre applied in the planting holes, and Nitrogen as ammonium sulphate nitrate (26 per cent N) at 0, 2 and 4 cwt. per acre applied as a top dressing. The treatments were combined factorially and three replications were used.

Planting was carried out using unrooted cuttings on 5th May, 1960, and in the succeeding two months only four inches of rain was recorded. Infilling was attempted because the spacing of 3 ft. by 2 ft. was wide, but most of the infills died owing to drought. The percentage of surviving plants averaged 79 per cent over the whole trial.

The plots were cut and individually distilled during the first half of November.

The results are given in Table IX in terms of green matter (cwt. per acre fresh material) and oil (lb. per acre) in Table X.

Table IX—Cwt. Fresh Material/Acre

	(Nitrogen) ASN Cwt./Acre			Mean
	0	2	4	
		±8·71 (1)		±5·03 (2)
Superphosphate cwt./acre—				
0	79·23	87·93	77·43	81·53
2	114·64	124·84	127·24	122·24
4	123·34	95·13	113·14	110·54
		±5·03 (2)		
Mean	105·74	102·63	105·94	104·77

Coefficient of Variation=14·4 per cent.

The increase due to 2 cwt./acre superphosphate is significant at the 0·1 per cent level.

Table X—Yield of Oil in Lb. per Acre

	(Nitrogen) A.S.N. Cwt./Acre			Mean
	0	2	4	
		±1·01 (1)		±0·59 (2)
Superphosphate cwt./acre—				
0	5·56	6·85	6·02	6·14
2	5·97	7·78	9·27	7·67
4	7·05	6·19	7·33	6·86
		±0·59 (2)		
Mean	6·19	6·94	7·54	6·89

Coefficient of Variation=25·5 per cent.

The increase due to 2 cwt. superphosphate per acre is not quite significant at the 5 per cent level (5 per cent significant level 1·75 lb./acre).

Analysis of the figures of percentage of oil based on fresh matter harvest weights showed no significant differences but, as the distilling apparatus was not equal to the task set to it, the oil yields were low and variable. With the experience gained from this first cut, the oil figures for succeeding distillations should be more uniform.

It should be noticed that, although the increase in oil yield is not statistically significant, it is an extremely economic return.

Soya Bean Variety Trial

A soya bean variety trial was laid down at Sotik after the long rains of 1960.

The seed was inoculated and nodulated well, although it was impossible to tell whether nodules were beneficial.

TABLE XI—RESULTS IN LB. PER ACRE

Variety	Yield
Ex Bukoba	1,412·3
Ex Congo	780·8
Hernon	704·0
Speckled	704·0
Ex Bukura	689·1
Mean	858·0
Standard Error	±96·9
Coefficient of Variation	11·3%

If field scale yields of this order can be obtained from "Ex Bukoba" it would be a reasonably profitable alternative crop to maize.

GROUNDNUT VARIETY TRIAL—HOMA BAY

Four varieties of groundnuts were placed in a variety trial at Homa Bay, because of the previous year's rather negative result.

Yields were extremely good and the results as given in Table XII are in lb. of shelled nuts per acre.

TABLE XII

Variety	Yield
Asiriye Mwitunde	1,972·3
Valencia Bunch	1,234·2
S720	1,137·4
Homa Bay (Local)	1,113·2
Mean	1,314·3
Standard Error	±355·2
Coefficient of Variation	26·0%

SORGHUM VARIETY TRIAL—HOMA BAY

The three best varieties (Dobbs White Ex Kongwa, TADA and S752) from the 1959 trial were included in a further trial with S394 and S344 in 1960.

The yields were again good.

TABLE XIII—RESULTS IN BAGS (200 LB.) PER ACRE

Variety	Yield
Dobbs White Ex Kongwa	15·61
S344	14·25
S394	12·89
S752	11·25
TADA	5·35
Mean	11·87
Standard Error	±2·11
Coefficient of Variation	17·8%

Fertilizer Studies—Sotik and Songhor Districts

In both Songhor and Sotik, the I.C.A. Soil Survey team carried out a survey and mapped the soils of the districts. Although the Sotik survey consisted merely of a section through the Settled area, it gave a basis for district fertilizer work.

(*a*) *Songhor*

It had been recognized that, in Songhor, nitrogen was the chief limiting factor.

Altogether, five trials were run in Songhor in which nitrogen treatments were incorporated. All except one gave economic increases. The exception was a trial which was sited at the head of the Mtete Valley being higher in altitude and having a marked soil difference from the rest of the sites.

It is impossible to give all the results but, of the four sites which responded to nitrogen application, the lowest response was a 35 per cent increase on maize to 2 cwt. per acre of calcium ammonium nitrate (20·5 per cent).

Results are given in Table XIV for the trial on Senetwa farm, Songhor, in bags (200 lb.) maize per acre, to illustrate the striking differences which nitrogen has made on some soils.

Table XIV

	Ammonium Sulphate Nitrate Cwt./Acre			Mean
	0	2	4	
		±1·13		±0·66
Superphosphate cwt./acre—				
0	8·63	16·89	20·38	15·30
2	10·56	17·75	21·50	16·60
4	10·19	16·78	19·14	15·37
		±0·66 (2)		
Mean	9·79	17·14	20·34	15·76

Coefficient of Variation=14·5 per cent.

A further interesting point emerged from the Songhor trials. In a maize variety/nitrogen application trial, the synthetic varieties responded far more to the 2 cwt./acre of sulphate of ammonia than the local entries. Whereas the local entries gave a 35 per cent increase only, the synthetics averaged a 75 per cent increase to the same dressing. A probable answer is that the local entries had been crib-selected over several years, when nitrogen application was not a general practice. The synthetic maizes have been bred on a fairly high level of fertility.

(*b*) *Sotik*

In Sotik, six NPK trials were laid down on the most important soil types mapped on the survey. Rates on all sites were the same, namely sulphate of ammonia (21 per cent N and superphosphate (42 per cent P_2O_5) each at 0, 2 and 4 cwt. per acre with muriate of potash at 0, 1 and 2 cwt. per acre.

Potash tended to decrease yields, and only on one site did nitrogen give a response. This was on a poor piece of vlei land, which lay waterlogged for most of the month of April.

The results of phosphate application were variable and it was unfortunate that the new land could not be obtained for each trial. On three of the sites land had to be accepted which had previously been dressed with phosphate and increases were not as spectacular as on the Experiment Station, where an 81 per cent increase was obtained to ? cwt. per acre of superphosphate on maize.

It would appear, from comparing soil test reports with responses obtained, that there is a rapid decrease in response to phosphate for a relatively small increase in p.p.m. available phosphate shown by the soil test. Thus on the station, where the soil report showed an average of 11 p.p.m. available phosphate, the percentage response to 4 cwt. per acre superphosphate was 85 per cent, whereas at Kipkebe which gave a phosphate figure of 26 p.p.m. the increase was only 8 per cent. The other trials supported this evidence.

In connexion with work on phosphate fertilizers, the figures in Table XIII, obtained from a trial in Sotik, might be of interest. These constitute the results of the second residual crop (maize). The trial was laid down in 1959, using potatoes as the test crop. This was followed by a bean crop in the short rains and by maize in 1960. The results shown in Table XV to phosphate and dung are residual effects from the original application. Only the nitrogen was reapplied.

Table XV—Results in Bags (200 lb.) per Acre

	Superphosphate Cwt./Acre			F.Y.M. Cwt./Acre			Mean
	0	1½	3	0	11	22	
			±2·06 (1)				±1·19 (2)
Sulphate of ammonia cwt/acre							
0	13·87	17·60	14·76	16·55	14·84	14·84	15·41
1½	17·60	20·50	24·38	16·33	21·55	24·61	20·83
3	12·82	19·01	24·08	16·33	19·91	20·28	18·84
Superphosphate cwt./acre							
0				9·54	16·63	18·12	14·76
1½				17·45	19·91	19·76	19·04
3				22·22	19·76	21·85	21·28
				±1·19 (2)			
Mean ..				16·40	18·77	19·91	18·36

Coefficient of Variation=19·4 per cent.

The recommendation, based on such results on very deficient soils, is that a heavy initial dressing be applied, perhaps even in the region of 4 cwt. per acre, followed by an annual application of 1 cwt. per acre.

Acknowledgements

It would be unfair to end a report without acknowledging the good work done by the officers at outstations. In this respect the work done by Mr. Stern and Mr. Walsh on trials in Songhor and Lumbwa areas is gratefully acknowledged. The help of Mr. Nicholson, farm manager at Sotik, is also gratefully recorded.

T. R. CHAPMAN,
Agricultural Research Officer.

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Weather

Although the total rainfall for the year was only slightly below average the distribution of effective rainfall has produced a most awkward year for the arable farmer. The long rains total at Katumani of 11·43 inches included two intensely heavy storms of over two and three inches, both of which were associated with a great deal of run-off and soil-wash. This water loss together with the short duration of the rains (six weeks) meant that most crops had to grow on under nine inches of water and were suffering from water stress from flowering time on. The short rains started well with 2·53 inches at the end of October. November, which normally produces four inches had six short ineffective showers totalling 1·06 inches. However rain in early December saved the crops at the last moment.

TABLE I—RAINFALL, 1960

	KATUMANI		KAMPI YA MAWE	
	Inches	Days	Inches	Days
January	0·21	2	0·36	3
February	0·69	5	0·05	2
March	4·32	9	4·10	11
April	5·94	15	6·83	15
May	1·17	6	1·01	5
June	0·02	1	0	—
July	0·96	2	0	—
August	—	0	0	—
September	0·05	1	0	—
October	2·53	7	4·03	6
November	1·06	6	0·10	1
December	6·44	13	2·31	9
Total	23·39	67	18·79	52

Beans

A study of rainfall probability in Southern Province has emphasized the extremely compact nature of each rainy season; the above figures for 1960 being fairly typical. It is obvious that for reliable yields it is essential to have varieties of crops which are sufficiently fast maturing to complete their life cycles within these short seasons. To this end a selection programme has been conducted among local and trade varieties of beans for the last few seasons. The table below includes the three varieties considered most suitable and the local Canadian Wonder for comparison.

TABLE II—YIELD OF DRY BEANS IN POUNDS/ACRE

Site and Season	Rainfall	Ex Nyasaland	Mich. Pea B.	White Idaho Flat	Canadian Wonder	Mean of other varieties in trial	L.S.D. P=0·05
Katumani L.R. 59 ..	11·51	1,590	1,240	890	—	1,200	220
Katumani S.R. 59 ..	4·15	280	210	260	120	160	90
K.Y.M. S.R. 59 ..	7·45	310	250	230	160	200	70
Katumani L.R. 60 ..	11·43	750	720	710	—	600	

The superiority of the variety Ex Nyasaland at all yield levels is striking. The long rains of 1959 at Katumani were well distributed and allowed the varieties to express their yield potential. By contrast the short rains were scanty and badly distributed and yield is expressive of the earliness of full flowering of each variety. None of the varieties exhibit drought resistance. The yield of the beans during the long rains of 1960 seems atypical until it is remembered that loss of water during two heavy storms, as noted above, reduced available water to around 9 inches.

The choice of the variety Idaho Flat is based on its extreme earliness and relatively high performance in bad seasons. Its yield in good seasons is low, possibly due to its susceptibility to bean rust which is prevalent in wet years.

The variety Ex Nyasaland is a small dark red bean obtained from the Plant Breeder, Lilongwe, Nyasaland.

Fertilizer Trials

During the last five years exploratory fertilizer trials have been conducted on most of the soil types in Southern Province. These trials have mostly taken the form of 2^4 factorials comparing presence and absence of superphosphate, sulphate of ammonia, sulphate of potash and farmyard manure. On nearly all these trials the most consistent and the largest response has been from double superphosphate. Two varieties of maize have been used on the trials; a long-term local white maize suited to the higher rainfall areas and a short-term maize, Taboran, for the low rainfall areas. Regression equations are presented for the response of each variety to 1 cwt. of double superphosphate on the lateritic loams and sandy loams in Machakos district.

I Local White Maize
$Y_p = 190 + 1{\cdot}011$ Y_0 with SE$\pm$152 lb./acre.
$r = 0{\cdot}995^{***}$ with 15 D.F.

II Taboran Maize
$Y_p = 118 + 1{\cdot}103$ Y_0 with SE 183 lb./acre
$r = 0{\cdot}967^{***}$ with 13 D.F.

where Y_p=yield of maize receiving 1 cwt. of double superphosphate and Y_0=yield of maize without superphosphate.

The most interesting feature of these equations is the nearly constant increase due to the superphosphate regardless of the yield level of the maize without phosphate. As rainfall is the determining factor on maize yield the response to superphosphate is relatively greater the lower the rainfall. The Taboran regression does show a 10 lb. increment to the phosphate response for each 100 lb. increase in yield without phosphate. This may be due to the high coefficient of variation of half the Taboran trials which is reflected in the Standard Error of the equation. From a yield:rainfall regression for Taboran produced by the Plant Breeder and rainfall probability tables the response to phosphate by Taboran should be in the region of 200 lb./acre three seasons out of four. As this response can be obtained over at least three seasons from one application of the fertilizer the return is worth nearly 300 per cent of the capital outlay to the African farmer.

A trial to study the value of different rates of superphosphate and the need for reapplication is complementary to the district trials mentioned above. A trial of this nature in the form of 4^2 factorial was started in the long rains of 1957 at Katumani on a lateritic red loam derived from gneiss. Unfortunately not all the treatments were applied at the correct time so that it has been impossible to distinguish clearly between the value of different rates of reapplication. Coupled with this, the trial has gradually acquired a higher coefficient of variation due to mechanical cultivations so that further sensitivity has been lost. However the results do give a good indication of the persistence of superphosphate and the need for reapplication.

The yields of local white maize in the first season of the trial are given in Table III. The double superphosphate is applied with the seed at each planting station.

Table III—Yield of Local White Maize Lb./Acre L.R. 1957

Nil	½ cwt./acre D/S	1 cwt./acre D/S	2 cwt./acre D/S
867	1,047	1,069	1,012

L.S.D. at P=0·05=129 lb./acre. C. of V.=12 per cent.

The increase is of the order to be expected from the regression equation given above and there is no further increase to the heavier rates, the ½ cwt./acre being sufficient.

By the fourth season three different times of application or reapplication had been imposed.

T_0=initial application.

T_1=reapplication every season.

T_2=reapplication every other season.

i.e. had received one reapplication in the third season.

Different rates of superphosphate still show no difference but the times of application show marked differences.

Table IV—Yield of Local White Maize in Lb./Acre S.R. 1958

Nil	T_0	T_1	T_2
905	1,504	1,780	1,573

C. of V.=24 per cent.

L.S.D. at P=0·05 between T_0 and T_1 or T_2=185 lb./acre P=0·05.

L.S.D. at P=0·05 between T_1 and T_2=214 lb./acre P=0·05.

The control plots are becoming worn out and are significantly lower than any other treatment. The response to the initial application (T_0) is still strong and is equal to one reapplication (T_2) in the third season. The reapplication at each planting (T_1) is significantly better than the initial application but just fails to be better than T_2.

By the seventh season the situation between the initial and reapplications of phosphate is exactly the same but within the initial application the ½ cwt./acre and 1 cwt./acre of superphosphate have almost disappeared while the 2 cwt./acre is still strongly in evidence (P=0·05). The variation of the trial is too great to determine any responses to the different levels of reapplying phosphate.

Table V—Yield of Taboran Maize in Lb./Acre L.R. 1960

Nil	T_0	T_1	T_2
608	818	1,130	891

C. of V.=25 per cent.

L.S.D. at P=0·05 between Nil and T_0=198 lb./acre
T_0 and T_1 or T_2=216 lb./acre
T_1 and T_2=250 lb./acre

TABLE VI—YIELD OF TABORAN MAIZE WITH INITIAL PHOSPHATE APPLICATION SIX SEASONS AGO

½ cwt./acre	1 cwt./acre	2 cwt./acre
630	743	1,046

Control=608 lb./acre. C. of V.=25 per cent.
L.S.D. at P=0·05=306 lb./acre

An interesting point emerges from the analysis of the third season: increased yield due to applying phosphate is closely related to the increased number of cobs in the stand of maize (r=0·8006*** with 19 D.F.). Correction for cob numbers shows that only with the reapplication of phosphate is there a significant increase in grain weight per cob. A similar situation is evident in the seventh season but the change from Local White to Taboran reduces the correlation. The reason for this loss of correlation can be found from the Plant Breeder's relation between yield and percentage of plants cobbing: Local White at the yield levels of the third season would have only 50 per cent cobbing while Taboran in the seventh season would have over 75 per cent cobbing and yield differences due more to differences in grain weight per cob.

The conclusions that can be drawn from this trial are that a 2 cwt./acre application of double superphosphate will last at least seven seasons but that an African farmer growing maize continuously would do better to apply a small amount (50 lb./acre) every season, placing the fertilizer with the seed. Once a farmer has started a rotation he should apply the superphosphate at 1 cwt./acre to his maize so that he can be assured of sufficient available phosphate for the other crops in his rotation.

Mixed Cropping, Maize and Beans

Two simple trials comparing maize alone with maize and beans together, and, maize and beans against beans at two populations were carried through four seasons at Katumani. Generally there is mutual depression in yield, always significant. The actual yields and the depression do not vary directly but are dependent on rainfall distribution and amount.

TABLE VIII—YIELD OF MAIZE AND BEANS IN LB./ACRE

Crop	S.R. 1957	L.R. 1958
Maize 3 ft. by 3 ft. ..	3,813	2,714
Maize 3 ft. by 3 ft. ..	2,906	1,777
Beans 3 ft. by 1½ ft. ..	445	784
Beans 3 ft. by 1½ ft. ..	484	1,190
Beans 1½ ft. by 1½ ft. ..	784	1,946

The short rains of 1957 were heavy and waterlogging and rust reduced the bean yields. The following rains were lighter but better distributed resulting in heavy yields of pure stand beans.

In a more typical season such as the long rains of 1959 with 11·5 inches of rain maize alone gave 1,790 lb./acre while the intercropped maize gave 1,380 lb./acre. If, however, the yields are assessed on their feeding value by converting to starch equivalent and the bean yield of the intercropped maize included there is a slight

advantage to mixed cropping; the starch equivalent production of the mixed crop being 1,520 lb./acre compared with 1,390 lb./acre for the maize alone. S.E. of mean = 50 lb./acre.

A similar situation exists with the beans. The intercropped beans yielded 920 lb./acre, the beans 3 ft. by 1½ ft. 1,452 lb./acre, and the beans 1½ ft. by 1½ ft. 1,820 lb./acre. In terms of starch equivalent, however, the maize and beans gave 1,792 lb./acre, the beans 3 ft. by 1½ ft. 956 lb./acre and the beans 1½ ft. by 1½ ft. 1,197 lb./acre. L.S.D. at P = 0·01 = 228 lb./acre.

A more complex factorial trial was planted in the short rains of 1959. This used three maize spacings (3 ft. by 6 in., 3 ft. by 1 ft., and 3 ft. by 2 ft.) with two bean spacings of one or two rows per row of maize, giving 29,000 and 58,000 plants/acre and pure stand plots. The poor season resulted in a very high coefficient of variation of 44·5 per cent for the maize yields giving no difference between maize spacings but marked differences between pure stand maize.

Pure stand maize, 1,148 lb./acre

Maize plus one row of beans, 517 lb./acre

Maize plus beans, 248 lb./acre.

These differences are significant at the highest level. When production of starch equivalent per unit area is considered with a pure stand unit divided half to maize and half to beans differences are reduced considerably:

Pure stand maize alone = 872 lb./SE/acre

Pure stand, half maize, half beans = 664 lb./SE/acre

Maize with one row of beans = 612 lb./SE/acre

Maize with two rows of beans = 447 lb./SE/acre.

Pure stand maize still produces the most food per unit area but difference between pure stand, half maize, half beans, and maize intercropped with one row of beans is not significant. The further depression from the second row of beans, however, is significant. (P at 0·05 = 142 lb./acre.)

It is obvious from these trials that maximum yields of either maize or beans can only be obtained when planted in pure stand and that maize properly spaced is the most productive of food in most seasons. If land is limited and beans have to be grown to provide protein it is debatable whether the maize and beans should be grown in pure stand or mixed. In both rains of 1957 and S.R. 58 there was little difference but in the short rains of 1957 the advantage was with pure stand.

R. H. BENNISON,
Agricultural Research Officer.

ANNUAL REPORT OF THE AGRICULTURAL RESEARCH OFFICER, COAST PROVINCE, 1960

Weather

Rainfall records for the three Research Centres were as follows:—

TABLE I

	Mtwapa	Matuga	Msabaha
	in.	*in.*	*in.*
January	0·40	0·42	Nil
February	Nil	0·34	0·03
March	2·44	1·97	2·67
April	9·20	8·50	8·82
May	16·01	11·70	10·59
June	8·12	5·31	8·74
July	3·75	1·31	2·93
August..	1·46	0·86	0·97
September	0·40	0·66	1·10
October	1·58	4·96	3·95
November	0·20	0·54	0·28
December	0·52	1·20	Nil
Totals	44·08	37·77	40·08

Cotton

VARIETY TRIALS

A trial was carried out at Msabaha to compare the three varieties U.K.51, U.K.58 and Ilonga Commercial. The plot size was 1/80th acre and the planting distance 3 ft. by 1½ ft.

This year the difference between yields has reached significance (P=0·001).

TABLE II—MEAN YIELD OF SEED COTTON IN LB./ACRE

	U.K.51	U.K.58	I.C.58
	1,194·4	1,243·3	1,034·3
L.S.D.	5% 95·6	1% 130·9	0·1% 178·4

Groundnuts

VARIETY TRIAL

Ten selections from Kibos were evaluated at Mtwapa. All were of the upright type and the planting distance was 18 in. by 9 in. on the flat.

There was no significant difference in the yields, the average of which was 1,575 lb. dry nuts per acre.

Maize

FERTILIZER TRIALS

A trial was carried out at Mtwapa to test the effect of three levels of urea on local white maize, and also to gauge the residual effect of gypsum applied in 1958. The maize was planted at 3 ft. by 1 ft.

TABLE V—MEAN YIELD OF MAIZE IN LB./ACRE

	Urea Cwt./Acre			
	Nil	¼	½	1
Nil	889·9	876·5	1,162·9	1,470·8
Gypsum 8 cwt./acre	853·9	1,079·4	1,381·2	1,589·3
		5%	1%	0·1%
L.S.D. between gypsum means		123·6	167·9	—
L.S.D. between urea means ..		71·1	96·8	130·8

The response to urea was linear (P=0·001). There was also a significant (P=0·05) residual response to urea which was not observed last year.

In the Shimba Hills, a further test crop of maize was taken on a trial area which received trace elements in 1958. A basic allocation of 1 cwt./acre ammonium phosphate and 1 cwt./acre urea has been given each year.

TABLE VI—MEAN YIELD OF MAIZE GRAIN IN LB./ACRE

A	Nil	—	1,610
B	Gypsum—8 cwt./acre	—	1,429
C	Manganese sulphate 25 lb./acre		1,505
D	B + C	—	1,445

As in previous years, there is no significant difference between the results.

Other fertilizer trials carried out in the Coast Province are reported by the Senior Soil Chemist.

PLANT BREEDING

Twenty-five Top Crosses, derived by crossing *Puccinia polysora* Resistant Maize with the Local White strain, were compared in a trial at Mtwapa. Differences between the yields were not significant; the average yield was 2,802·4 lb./acre.

Cassava

VARIETY TRIAL

Sixteen mosaic resistant varieties ex Amani are at present under trial at Mtwapa.

From observations to date, the two varieties 53121/22 and 46106/27 have again proved superior in establishment and resistance to mosaic. Both these varieties are being bulked for distribution.

Further varieties have recently been introduced from Amani.

Tree Crops

Losses in the Establishment Trials of coconuts and lime trees at Mtwapa have been very heavy. The factors responsible for these losses are being investigated.

Bixa orellana has been successfully established in a number of plots throughout the Province. However, at Msambweni and Hindi it has failed to flower, whereas at other sites heavy crops of pods have been produced in the first year after planting. When harvesting, the terminal dusters are cut off above a bud, thus carrying out the harvesting and pruning in one operation. The pods are then sun-dried and threshed to extract the seed.

Fodder Crops and Leys

Napier Grass has been successfully established at Mtwapa. Yields of 1·8 tons per acre have been obtained from a single cut when the grass is 4–5 ft. high.

Mixtures of Sudan Grass and Sunn Hemp, and Napier Grass and Velvet Bean have been ensiled successfully with the use of molasses.

Of the introduced grasses included in observation plots at Mtwapa, Nandi Setaria, Slender Guinea Grass and Rhodes (Endebess) all failed to survive. *Cenchrus ciliaris* planted at 3 ft. by 1 ft. grew well but failed to tiller. Consequently, the ground cover was poor and weed encroachment occurred. Establishment from seed, and also mechanical planting is now to be tried.

Animal Husbandry

Jerseys have been introduced at Mtwapa, where the aim is to build up a herd of eighty milking cows. The climate has not yet had any adverse effect on these animals. Under judicious management aimed at minimizing any heat stress, it should be possible to maintain these exotic animals in a state of high production if the problems of dry season feeding can be overcome. Unfortunately, seasonal calfing cannot be employed because of the necessity to supply a whole milk market.

R. C. GRIMES,
Agricultural Research Officer.

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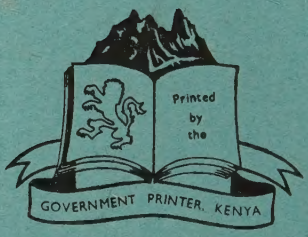
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